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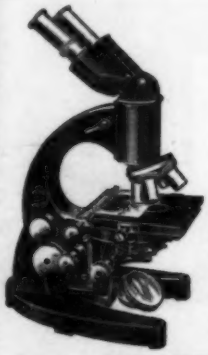

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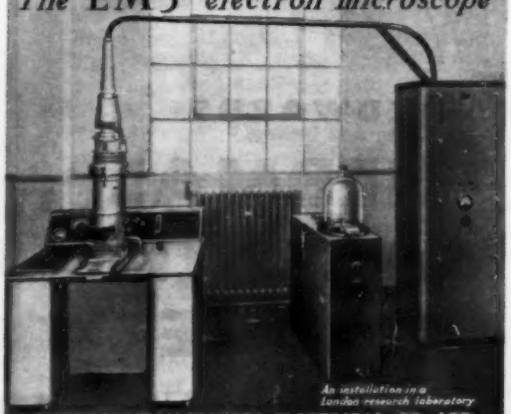

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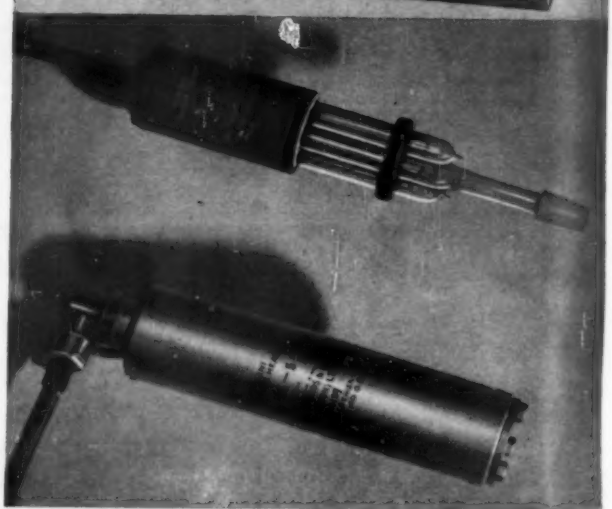

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BROADCASTING IN GREAT BRITAIN

FROM several points of view, the report* of the committee under the chairmanship of Lord Beveridge which has been considering the future of broadcasting in Great Britain is of great interest to scientific workers. It deals, especially in the chapters on higher-frequency broadcasting and on television, with technical matters with which some are specially and directly concerned; indeed, the policy to be followed by the Corporation in some respects must depend very closely upon the rate of scientific and technical advance in those fields. The educational aspects of broadcasting are likewise of direct interest, for scientific men need no reminder that broadcasting as an influence on men's minds has great possibilities, either for good or for evil. It is indeed a power as great in its way as atomic energy, and on its wise use the peace and sanity of the world largely depend.

Broadcasting in Great Britain, however, has hitherto been a monopoly, though a monopoly independent of the State, and there are issues arising out of that aspect of broadcasting which are of very wide importance. Regarded as a public corporation—and Lord Beveridge and his colleagues, with one dissentient, recommend the continuance of broadcasting as a monopoly—the British Broadcasting Corporation is of more than passing interest as a study of the relations between government and the public corporation, of the way in which power and responsibility are linked and some degree of ultimate public control exercised. There are problems of keeping such an independent body in touch with the public it serves, problems of the maintenance of standards and problems of professional and of staff relations.

On all these matters the report has much to say that is sound and wise. Overshadowing all in importance, however, is the issue of monopoly, and the question whether or not that should be continued. Only if an affirmative answer is given is it profitable to examine in detail the measures which can be adopted as safeguards against the dangers of monopoly, though admittedly an affirmative answer could scarcely be given without some assurance that effective safeguards exist.

"Broadcasting," says the majority report in a passage quoted again by Mr. Selwyn Lloyd in his minority report, "is the most persuasive, and therefore one of the most powerful of agents for influencing men's thoughts and actions, for giving them a picture, true or false, of their fellows and of the world in which they live, for appealing to their intellect, their emotions and their appetites, for filling their minds with beauty or ugliness, ideas or idleness, laughter or terror, love or hate." Elsewhere the report observes: "if broadcasting can find a serious audience it is an unrivalled means of bringing vital issues to wider understanding. The evil is that broadcasting is capable of increasing perhaps the most serious of

* Report of the Broadcasting Committee, 1949. (Cmd. 8116.) Pp. vii+327. (London: H.M. Stationery Office, 1951.) 6s. 6d. net.

all dangers which threaten democracy and free institutions to-day—the danger of passivity—of acceptance by masses of orders given to them and of things said to them. Broadcasting has in itself a tendency to encourage passivity, for listening as such, if one does no more, is a passive occupation. Television may be found to have this danger of passivity in even stronger form."

This appears to be the main reason for Mr. Selwyn Lloyd's disagreement with the majority report: he holds that it is not in the public interest that all this actual and potential influence should be vested in a public or private monopoly. The four principal evils of monopoly are: size and unwieldiness; complacency and rigidity, leading to hindrance of development; the existence of only one employer; and excessive power; and the last is regarded by him as most serious. A memorandum submitted in evidence by Mr. Geoffrey Crowther and Sir Robert Watson-Watt, which included a scientific argument to prove the possibility, through the use of very-high-frequency broadcasting, of establishing at least three competitive corporations, also referred to the danger that excessive power over men's thoughts concentrated in a single organization would lead to complacency, lack of imagination, and deadly uniformity of public opinion. This memorandum concluded with a strong appeal for freedom and competition, urging that the only ultimate safeguard of liberty lies in diversity, and that the Committee's report would be a critical factor in the resuscitation or the destruction of the free society.

The other members of the Committee were fully alive to these dangers and arguments; but they firmly reject, as a guiding principle in broadcasting, competition for numbers of listeners. Such competition, they hold, is fatal to any social purpose, though they do not accept the assumption that in broadcasting a monopoly alone can have high standards and social purpose. Nor, in spite of their generous tribute to the past achievements of the B.B.C., do they accept the argument that the B.B.C. should therefore be continued on exactly the same lines as in the past. The Committee differs from the critics of monopoly in means rather than in ends, and believes that the ends which all desire can be better served by a single chartered corporation for the United Kingdom, including the overseas services and television, as well as sound broadcasting, subject to appropriate internal and external safeguards against abuse of power.

Nevertheless, the Committee in this report appears to dismiss the argument against monopoly a little too summarily. The evidence collected by Mr. R. H. Coase, for example, in his recent study of this aspect of British broadcasting, suggests that public discussion of this issue is only just beginning. The new charter should not prejudice such discussion, especially since the Beveridge Committee itself recognizes that developments in very-high-frequency broadcasting may not only assist in achieving a prime purpose of the B.B.C. by enabling it adequately to cover the United Kingdom by sound broadcasting, but may also make possible more diversity and independence of programmes. The Committee rightly maintains that the placing of sound broadcasting throughout Great Britain on a more satisfactory basis in respect of reception than it is to-day should be regarded as an aim of very high priority. Furthermore, it realizes that, if certain difficult technical and practical problems are solved, exploitation of higher frequencies in sound broadcasting opens the possibility of transforming the wave length situation and of adding local to centralized broadcasting. It has not, however, recognized that such developments may also profoundly affect the monopoly position and the possibility of competitive broadcasting, as well as its own proposals for devolution. The balance of informed opinion may be against terminating the monopoly at the present time; and while the Committee may well be right in recommending that the whole question should not be re-opened in five years time, with all the difficulties that such an impending investigation would hold for the planning of broadcasting, it is not quite clear that there should be no fixed time limit for the new charter. That might well have been set at fifteen years, unless in the meantime the committee charged with the responsibility for a quinquennial review of the finance, work and policy of the Corporation advised the Government that technical developments made it advisable to reconsider this issue of monopoly.

There should not, even then, be the need to make so exhaustive a review as the Beveridge Committee has done. It is clear from the report that the Committee has recommended that the duration of the new charter should be indefinite, essentially because it cannot be foreseen when technical developments or social changes will make a new fundamental inquiry appropriate. Provided it is realized widely that this recommendation is not intended to prejudge the issue of monopoly, no great exception need perhaps be taken to it. The more immediate practical issue is the scrutiny by public opinion of the safeguards against abuse of monopoly which are recommended in this report, and particularly from the point of view of ensuring not only enterprise but also efficiency.

The majority recommendations of the Committee will probably obtain ready assent in Parliament; but some of the other proposals, particularly those relating to the safeguards against abuse of monopoly, may well be the subject of considerable further debate. First, there is the problem, given the continued independence of the broadcasting authority, in programme policy and in general administration, which is a corner-stone of the Committee's proposals, of making a public-service monopoly subservient to the public without recourse to direct parliamentary control. The Committee's rejection of the latter will be endorsed by some who do not follow it in its exposition of the way the governors must assume the function of a Minister in keeping his department in touch with public opinion and subject to external criticism.

Apart from these details, however, there is still the issue of parliamentary responsibility. As regards Ministerial responsibility, the Committee makes no

recommendation beyond indicating the need for clear decision, and that responsibility for allocation of wave-lengths or collection of revenue should rest with the Postmaster-General. Nevertheless, on the evidence in this report, it seems clear that the responsibility of the Government in such matters as the appointment of governors, the exercise of the powers of veto and instruction, the prescription of information to be furnished by the Corporation to Parliament, the appointments of the quinquennial committee of review and of the Television and Higher Frequency Advisory Committee, and the like, would be more appropriately discharged by the Lord President of the Council than by the Postmaster-General.

For the rest, the Committee proposes that the Corporation should be required to include specified information in its published reports and accounts. On the conduct of its finance, the report, indeed, pays a very high tribute to the B.B.C.; but it is also pointed out that, although the Corporation knows practically everything that needs to be known about its own financial operations, it has told Parliament and the public very little about them. Both Parliament and the public are, in the opinion of the Beveridge Committee, entitled to much more than the minimum of information required by statute of private companies; and the decision as to what information is desirable should be taken by the Government and not by the B.B.C., though the latter should be consulted. The decision should be the Minister's, and it must be defended by him if challenged in Parliament. This annual report would also be supported by the 'independent' quinquennial review already indicated, which would cover the action taken by the governors on the recommendations of the Beveridge Committee. The charter, it is proposed, should also name certain purposes which the governors would be required to pursue, though leaving them free as to method. Two of them—the development of very-high-frequency broadcasting and television—have already been mentioned: the remaining three relate to bringing the work of the Corporation under constant and effective review from outside; provision for effective staff representation and discussion; and regional delegation to broadcasting commissions for Scotland, Wales and Northern Ireland.

The new conception of the functions of the governors of the B.B.C. which are implicit in this report should be noted. They are visualized as agents for informed democratic control, collectively the equivalent of a Minister, and their continued appointment for part-time rather than full-time is intended to keep them responsive to public opinion. They are also to be provided with a channel for both popular and expert criticism from outside, and for this purpose a public representation service is proposed which, besides taking over audience research, would also be responsible for such functions as receiving and reporting on external criticism and suggestions, the critical review of home programmes, and the systematic review of overseas programmes, suggestions for the establishment of advisory committees and the study of broadcasting methods and programmes in other countries. It is emphasized that a principal purpose of the suggested public-representation service would lie in making it possible for the governors to get carefully considered reports of criticism upon programmes. Some weight is also attached to the suggestions for increasing the organization for specialist advice which already exists, and for further experiment with advisory bodies by the regional commissions already mentioned.

The governors are also regarded as responsible to some extent for the interpretation or explanation of the Corporation to the public; from this point of view the report raises the question of the civil rights of governors, and urges the need for further clarification of their position, for example, as members of the House of Lords when broadcasting questions are debated there. At such times intricate constitutional questions may be raised, as well as that of the independence of individual governors and their rights.

This view of the functions of the governing body leads to some important problems in relation to the general administration of the Corporation. The Committee clearly recognizes that some delicate questions are raised by its observations on relations with the board of management, and on those between the director-general and the chairman of the board of governors. How critical such relations can be no reader of Lord Reith's "Into the Wind" will need reminding. It does not appear, however, that the Beveridge Committee appreciates the extent to which its proposals may blur the distinction between broad oversight of policy and day-to-day management, and make efficient administration just as difficult as under direct parliamentary control. The whole of the complicated advisory apparatus which is proposed appears to be directed to the board of governors, and not to those carrying the immediate administrative responsibility.

The main criticism to be made of the proposals is, in fact, that they tend to weaken the authority of the director-general and of the central organization of the Corporation. By weakening the power of responsible decision, insisting on too many checks and balances, and making it necessary for executives to force every decision through a network of committees, the proposals may well make the B.B.C. even more bureaucratic than at present. More important still, they may make it much more difficult to secure and keep executives with the vision, enterprise and decision that are imperative if monopoly broadcasting is to avoid the dangers of timidity, complacency and unadventurousness.

The proposals for three regional broadcasting commissions, though not without difficulties, seem much more promising. Indeed, Mr. John Coatman has pointed out that the Committee might well have gone further and with advantage have included regional commissions for England as well, thus minimizing the dangers of exaggerated nationalist sentiment inherent in the present proposals. The Committee was impressed by the comparatively small contribution to regional programmes which was of

local origin, by the limited scope of the existing regional advisory councils and by the advantage, from the point of view of staff, of the relatively small organization of a region over that of London. It was less impressed by demand for autonomy voiced both in Scotland and in Wales, though it recognized the dangers which could attend excessive centralization. But in its concern not to break British broadcasting into fragments, it does not appear to have pursued the idea of federation sufficiently, or to have provided for the regional devolution in England which is equally, if not more, important than in the three regions suggested, if the full regional contribution is to be secured.

The regional development of broadcasting is attended with certain technical difficulties on the financial side, which may make it of less general interest from the administrative point of view than most aspects of the Corporation's organization. The extent to which the Corporation has so far been independent of the political field also makes its experience rather less relevant to that of other experiments in public ownership and control, though exploration of the issue of Ministerial responsibility as recommended might be illuminating. Nevertheless, there is much in this report that bears closely on the problems which the nationalized industries are now facing, and some of these are to be found in the minority report and in the notes and reservations of individual members of the Committee which are appended.

Few big public or private corporations could have emerged, as the British Broadcasting Corporation has done, from so searching an inquiry with such credit, but if the future is to show as distinguished a record, there must be no lack of the stimulus of informed and constructive criticism. No matter how excellent the internal organization of such a body, such criticism is the ultimate safeguard against abuse of power, and above all is the final means by which we can ensure that broadcasting is fully developed and utilized to assist a democracy to understand the issues upon which it may be required to vote or act.

REFERENCE-BOOK OF DAIRYING

A Dictionary of Dairying

By Dr. J. G. Davis. Pp. xx+856+76 plates. (London: Leonard Hill, Ltd., 1950.) 37*s.* 6*d.*

THERE has always been a dearth of British text-books on dairying, apart from works dealing with particular branches such as dairy husbandry, dairy chemistry and dairy bacteriology. In view of the extensive literature now devoted to publication of original work in the fields of dairy science and technology, the lack of complementary standard text-books is felt acutely by investigators, teachers and practical dairy workers. Certainly there is a wide choice of American text-books; but unfortunately many of these are inadequate, and all refer to conditions which frequently differ from those met with in Great Britain. In a single volume, Dr. J. G. Davis and his twenty-eight collaborators have now amassed the broad fundamentals of modern dairying, covering the scientific, technological and economic aspects. True, this is not a text-book, but rather, as the title indicates, a work of reference arranged alphabetically; nevertheless, it will be very widely used.

In an omnibus work of this character considerable variation in treatment is almost inevitable, and consequently there are differences in quality between the various sections. Some subjects are accorded the briefest—occasionally superficial—reference, while others (particularly contributed sections) receive an approach to detailed text-book treatment. Purely scientific matters are, perhaps, accorded the major emphasis. In order to confine the whole field of dairying within restricted bounds, most subjects have, very wisely, been limited to the bare minimum. Nevertheless, the information given is basically sound and readily intelligible; in addition, numerous cross-references are employed and further sources of detailed information are indicated.

Certain fields wherein the existing literature is deficient or confusing have been selected for more detailed treatment. In his choice of such material the author has on the whole been very happy. Thus, it is particularly pleasing to find useful sections dealing with milk-bottle fillers, bottle washing, and the problems of detergency in dairy practice. Some of the material presented in the sections on dairy management and the costing of milk distributive operations is also original and will no doubt provoke discussion. Other relatively long sections deal with the isolation and identification of lactic acid bacteria, coliform bacteria, thermophilic and thermoduric bacteria, bacteriological grading of milk, cleansing and sterilization of dairy plant, water supplies for dairy premises, dairy effluent disposal, cooling of milk at the farm, the pasteurization of milk, and the manufacture of ice cream, cheese, condensed milk and dried milk. The summaries of recent research findings in these fields will be valuable to many. Dairy bacteriology tends to receive more emphasis than does dairy chemistry, but this is the present fashion.

Notwithstanding the immense labour involved in the production of this volume, a few further additions may perhaps be suggested. The essential dairy services might receive more generous treatment; thus steam raising, a basic requirement of all dairy operations, is scarcely mentioned and the references given are inadequate, while the use of electric power for dairy purposes is accorded similar treatment. A special section on the design of dairy buildings and the lay-out of plant would be valuable. It is surprising to find little information on the general properties, processing and marketing of liquid cream; in spite of present restrictions in Britain, cream production is an important dairying activity which merits more extended treatment. The production of infant foods, which absorbs large quantities of milk, might also find a place. The problems of milk transport other than retail delivery, and the design and standardization of milk containers are other important matters which deserve fuller discussion. Throughout the book a more generous use of explanatory diagrams, as opposed to illustrations, would assist non-expert readers. These omissions are relatively small matters which can be put right in future editions.

The "Dictionary" will undoubtedly become a standard work of reference. Indeed, the appearance of this encyclopædic volume (at an unusually modest price) is quite an event in the dairying world.

E. L. Crossley

STATISTICS FOR EXPERIMENTAL DESIGN

Experimental Designs

By Prof. William G. Cochran and Gertrude M. Cox. Pp. ix+454. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1950.) 46s. net.

THIS book is essential to every statistician concerned with experimentation. When the discipline of experimental design was first introduced into quantitative biological research, materials and treatments were made to conform to one or two simple patterns, notably the randomized block, Latin square, and simpler factorial types; more recently, the trend has been reversed, with the better purpose of constructing designs that will compare the treatments most precisely within the limitations imposed by the materials. The consequent proliferation of designs has made difficult even the remembering of where papers describing their construction and analysis may be found. Here, for the first time, is a codification of most of the simpler and more useful types.

After an introductory chapter describing the role of statistical science in the planning of experiments, Chapter 2 explains how precision can be modified by replication and by grouping experimental units into blocks. The general principles of the analysis of variance and covariance are expounded in a long third chapter; the basic linear model, and the meaning and advantages of orthogonality, are particularly well illustrated. These three chapters deserve study by all who use statistical science, for they form an excellent account of the relationship between the arrangement of an experiment and its statistical analysis.

Apart from a short chapter on randomization, the remainder of the book consists of systematic discussion of different designs. Randomized blocks, Latin squares, factorial designs (unconfounded and confounded), quasi-Latin squares and the various types of incomplete block designs—balanced and partially balanced, rectangular and cubic lattices, lattice squares, and Youden squares—are all described, with many numerical examples drawn from agricultural, biological, and industrial research. Unless the method of construction is obvious, plans are shown for each type of design, with various numbers of treatments; these plans are indexed according to number of treatments and degree of replication, so that the user may easily find one suited to his needs and has then only to randomize the arrangement. This section of the book will be used for reference rather than for consecutive reading, though it could be the basis of an excellent course of instruction.

Had the authors done no more than list designs and methods of analysis they would have performed a valuable service. In addition, their extensive experience of statistical science has enriched their catalogue with an immense amount of information and advice about the interpretation of experiments. The importance of assumptions used in the analysis of variance, the analysis of experiments when some observations are missing, and the interpretation of series of experiments are among the topics so considered.

When the feast is so bountiful, to ask for more dishes may seem unkind: nevertheless, we must hope that the authors will give us either a second volume or an expanded second edition. Further consideration of 'mixed' confounding schemes, especially of the incompletely balanced types that are sometimes inescapable, would be helpful. Fractional replication of factorial designs introduces special problems of interpretation, and the absence of numerical examples might be remedied. More might be said about long-term agricultural experiments. Finally, Rao's suggestions for a standardized method of analysis for incomplete block designs might provide an escape from the difficulty of learning a different computational scheme for each type. These remarks relate not to blemishes but to points of departure for future work. "Cochran and Cox" is already, and will long remain, the standard guide to experimental design.

D. J. FINNEY

HUMAN BLOOD GROUPS

Blood Groups in Man

By Dr. R. R. Race and Dr. Ruth Sanger. Pp. xv+290. (Oxford: Blackwell Scientific Publications, Ltd., 1950.) 30s. net.

AT the beginning of the century, Landsteiner described the discovery of the *A*, *B* and *O* blood groups in man. Since that time many efforts have been made to discover other human blood groups. Such methods were by using as test sera suitably absorbed animal sera, and later by the injection of human red cells into animals. This latter method led to the discovery of the *M*, *N* and *P* groups. Subsequent experiments involving the injection of monkey blood into rabbits and guinea pigs and the testing of such antisera against human cells led Landsteiner and Wiener in 1940 to the discovery of the *Rh* blood group.

From this point onwards the discovery of new human blood groups advanced rapidly. This was due not only to the discovery of the *Rh* group, but also to the fact that this group was found to be the main agent in iso-immunization during pregnancy and the cause, in many cases, of haemolytic disease of the newly born. In certain cases the antibodies formed were due to other blood groups. A further factor has been the increasing use of blood transfusions and the study of the occasional reactions resulting from these; this was the way in which the recent 'Duffy' blood group was discovered. New techniques have also been devised for the detection of iso-antibodies, and notable among these have been the use of an anti-human globulin serum for detecting incomplete iso-agglutinins.

This book, by Drs. R. R. Race and Ruth Sanger, describes all the new ideas and the techniques which have been developed within the past ten years and also gives a complete and comprehensive description of the inheritance, characters and method of detection of the human blood groups. The study and understanding of blood-group inheritance is indeed important for, as Prof. R. A. Fisher states in a foreword, there is now a good marker on nine out of twenty-three autosomes; eight of them are blood-group markers.

The book is very readable and inspiring for one who works in this particular field of blood-group serology. One of the most valuable sections is that on the identification of antibodies and the determination of the nature of unknown antibodies occurring in human sera. For the general scientific worker,

geneticist and perhaps clinician, the work is difficult to understand and really would be better described as recent advances in the study of blood groups. It would be advisable, therefore, for anyone unacquainted with this particular field, or wishing to gain further knowledge of it, to read some preliminary work in the first instance. The descriptions of techniques in this book are somewhat less complete than one would have liked: but it is probable that the authors feel that practical experience is the only way to learn these techniques properly, since they say, in referring to the testing of *Rh*-antigens, "to achieve accuracy a long apprenticeship in error seems necessary".

Drs. Race and Sanger are to be congratulated on the production of this book, which is packed with knowledge, free from mistakes, and will form an invaluable reference book for all biologists and geneticists; but its proper place for those actually working in this field will be beside them on the laboratory bench.

F. Stratton

SPECTROSCOPY—EXPERIMENTAL, THEORETICAL AND IMAGINARY

Practical Spectroscopy

By C. Candler. Pp. viii+190+4 plates. (London: Hilger and Watts, Ltd., 1949.) 21*s*. net.

Absorption Spectrophotometry

By G. F. Lothian. Pp. 196. (London: Hilger and Watts, Ltd., 1949.) 26*s*. net.

An Introduction to Molecular Spectra

By Dr. Raynor C. Johnson. Pp. xiii+296+8 plates. (London: Methuen and Co., Ltd., 1949.) 40*s*. net.

The Interpretation of Spectra

By William Mayo Venable. Pp. v+200. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1948.) 48*s*. net.

THE first two of these books deal with the experimental side of spectroscopy, mainly with Hilger instruments, and indeed are to some extent glorified instrument catalogues. C. Candler's book is most ably written and gives the benefit of his expert knowledge on the subject, but it is not to be regarded as a comprehensive "Practical Spectroscopy". It is a course for students using a wave-length spectrometer and accessories. It covers qualitative and quantitative spectrochemical analysis, absorption spectra, Raman spectra, the infra-red region and some interferometry. More than a hundred experiments are suggested, and certainly no one with this book who was planning a course in spectroscopy would be short of ideas for experiments, although many of them seem rather elaborate and require a lot of accessory equipment not normally available in a teaching laboratory. The emphasis is rather chemical.

The same is also true of G. F. Lothian's "Absorption Spectrophotometry". This book is, however, a fairly comprehensive treatment of the subject, and, although the use of Hilger instruments is to the fore, others such as the Perkin–Elmer and Grubb–Parsons infra-red spectrometers are briefly described. This book covers the experimental technique, for the ultra-violet and visible, by photographic, photo-electric or visual means, and also for the infra-red. I would like to have seen an extension to cover the technique of measurements at liquid-air temperatures, and I think that the troublesome Eberhard effect in photographic work is dismissed rather lightly. The book is very well illustrated, both with instrumental photographs and absorption curves. The principles and terminology are clearly dealt with, and the applications of spectrophotometry to inorganic and organic analysis, to biological problems and to the elucidation of the structure of complex molecules are described.

The most important of the four books under review is "An Introduction to Molecular Spectra", by Dr. R. C. Johnson, which covers mainly the spectra of diatomic molecules but includes chapters on the Raman effect, on the electronic and infra-red spectra of polyatomic molecules and on applications of molecular spectroscopy to astrophysics, chemistry and biochemistry. The treatment is from the point of view of an experimental spectroscopist endeavouring to systematize a spectrum, and Dr. Johnson gives the reader the benefit of his very considerable experience in this field, his treatment of the vibrational and rotational structure of the spectra of diatomic molecules being very clear. This section is, however, rather marred by being badly out of date, many examples being, as a result, unsuitable; there are a few errors and omissions—on p. 152 the formulæ for rotational intensity factors are likely to lead to trouble because it is not stated that the value of K to be used is whichever is the greater of K' or K'', the rotational quantum numbers in the upper and lower electronic states. No knowledge of wave mechanics or group theory is assumed, and the book is clearly written and easy to read. It thus forms a valuable introduction to the subject and may be recommended.

In "The Interpretation of Spectra", W. M. Venable gives an original and highly unorthodox interpretation of the cause of spectra. It is difficult to know whether to ignore, laugh at or seriously to criticize this work. The last approach is probably the best; but is the most difficult in a limited space. The whole treatment is rather complex because of the detailed numerical data cited and the use of a lot of algebraic expressions. The first part seeks to establish relationships between the primary and secondary spectrum of hydrogen. Mr. Venable then rejects the Bohr-type model of atomic structure on the grounds that on electromagnetic theory a moving electron will radiate and cannot form a stationary energy state. He assumes that in equilibrium the electron is poised at a distance from the nucleus by the usual attractive force varying as $1/r^2$ and a repulsive force as $1/r^3$. Scattering experiments showing that the $1/r^2$ law alone holds down to very small distances adequately disproves this part of his theory. The author then assumes that a single atom can give only continuous radiation, and invokes oscillations of electrons in the field of complex atom-groups or "line-molecules" to account for line spectra. Such a theory could not explain the line absorption spectra of cold monatomic gases (for example, the absorption of λ2537 of Hg in laboratory air) or the absence of marked pressure dependence. Little attempt is made to deal in detail with molecular spectra, the complex structure of which has been explained so well in terms of orthodox theory.

The book may be recommended to nuclear physicists; they will find the last chapter very amusing. It is a pity, though, that so much obviously painstaking work and original thought has not been put to better use.

A. G. Gaydon

A PALYNOLOGICAL TREASURE-HOUSE

By Dr. H. G. BAKER
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FRANZ ANDREAS (FRANCIS) BAUER was born in Feldsburg, Austria, in 1758. He settled in England some thirty years later as a result of a meeting with Sir Joseph Banks, who gave him employment as an artist at the Royal Gardens in Kew, where his title eventually included that of 'Botanical Painter to His Majesty George III'. During his life at Kew (which ended in 1840) he produced illustrations of complete and dissected plants which are consistently of the very highest quality. Yet much of his work has remained generally unrecognized, a situation which has only recently been improved by the devotion of a chapter to this great artist and his brother by the chroniclers of "Botanical Illustration", Blunt and Stearn[1]. Nevertheless, the drawings made by Francis Bauer of microscopical subjects are scarcely dealt with by these historians, who are, naturally enough, concerned almost entirely with habit studies of flowering plants.

In the historical section of his book on "Pollen Grains", Wodehouse[2] gives a list of species the pollen-grains of which have been drawn by Bauer. These drawings, which were never published, are bound together in a single volume which is in the Botanical Library of the British Museum (Natural History) at South Kensington. It bears the title "Drawings by Francis Bauer, F.R.S., Epidermis, Hairs, Pollen Grains, Monstrosities".

The primary object of my own consultation of this volume was to see whether or not Bauer had observed the pollen-dimorphism which is to be found in the tribe Staticeæ of the Plumbaginaceæ. The discovery of this dimorphism is usually attributed to MacCleod[3], who described it (without appreciating its significance) in *Limonium vulgare* Mill. in 1887. However, Bauer, who studied the pollen of *Armeria maritima* Willd. (as '*Statice Armeria*'), appears to have used only one, or at the most two plants, yielding only the type of pollen we now call Type *B* [4] but which he has depicted with considerable accuracy. Three tricolpate grains are shown in Plate 64, apparently bursting because, like so many of the grains illustrated, they had been mounted in water. Others are shown in Plate 70 (see Fig. 7).

Type of illustration	Identity of material	Plate	Date
Upper epidermis of leaf	Various genera	4–15	1800
Hairs	*Alyssum creticum*	26	1798
,,	*Lycopsis arvensis*	32	1798
Pollen grains	"*Grevillia sulphoria*" (*sic*)	55	June 15, 1833
Sporangia and style	Ferns and unnamed Angiosperm	58	Feb. 1, 1804
Pollen grains	"New *Oncydium* K.G." (presumably Kew Gardens)	61	Mar. 14, 1834
,, ,,	"*Plargonium* (*sic*) *inquinans*"	63	June 1833
Bladder	*Utricularia*	69	July 27, 1831 (also Aug. 18)
Pollen grains	"*Epidendrum Barringtonia*" (*sic*)	73	May 22, 1802
Pollinia and stamens	Orchid	74	Nov. 16, 1804
Pollen grains	*Strelitzia Augusta*	77	Feb. 1821
,, ,,	"*Caladium* ?"	77	May 7, 1821
,, ,,	*Rhexia Cotyledon*	77	May 25, 1821
,, ,,	*Isopogon* sp.	80	Mar. 19, 1836
,, ,,	"New Yellow, H.S. Garden"	80	1833
Floral parts	*Centaurea* sp.	99	July 1819
Shoot bearing berries	*Viscum album*	100	Jan. 1, 1833

If there was disappointment in this quest, the study proved to be amply worth while. To begin with, it was possible to bring nearer settlement the uncertain matter of the dates when these drawings were made. We are indebted to Wodehouse[2] not only for a list of species drawn by Bauer, but also for an expert appraisal of the quality of these relatively inaccessible illustrations. The list is, unfortunately, not complete, but it includes more than 175 species drawn from some fifty-seven families. Wodehouse suggests that the work may have extended over a considerable period, possibly from 1790 until Bauer's death in 1840. However, circumstances concerned with the illustrations elsewhere of the pollen of a certain orchid (to be referred to later) led him to postulate (with an admission of improbability) that the collected drawings might all have been prepared between 1832 and 1840.

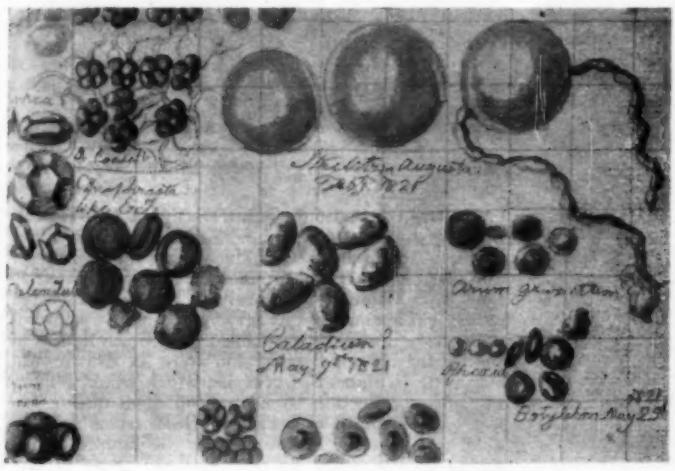

Fig. 1. Pollen-grains of several species from Plate 77, some dated

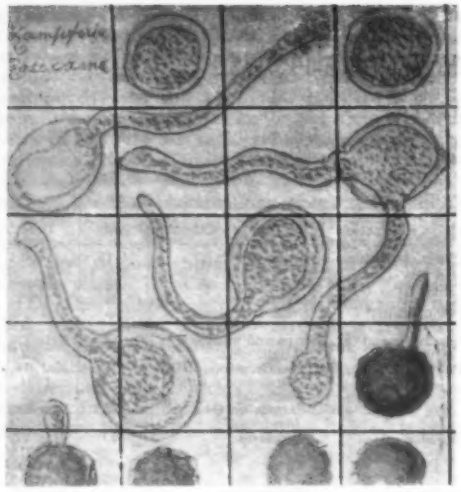

Fig. 2. Germinating pollen of *Kæmpferia Roscoana*, from Plate 80

The first new evidence to emerge was the discovery that, contrary to the statement by Wodehouse, several of the illustrations are accompanied by dates (see the table and Fig. 1). Several tentative conclusions may be drawn from the evidence of these dates. In the first place, it seems that Bauer was concerned with drawing the epidermes and hairs of various genera before concerning himself with pollen-grains. This seems a natural progression from the more obvious to the more intricate, and there is little reason for doubting that all the drawings of pollen-grains were made in the nineteenth century. The earliest dated example is that of the orchid *Epidendrum Barringtoniæ* (= *Lycaste Barringtoniæ*) (Plate 73, May 22, 1802) and the latest the *Isopogon* of Plate 80 (March 19, 1836). From the table it will be seen that even among those concerned with pollen-grains, the plates are not arranged chronologically. Nevertheless, it is reasonable to assume that drawings on the same plate as a dated example are more or less contemporaneous (even though the dates 1833 and 1836 do appear on the same Plate 80). It is likely that all the drawings of pollen-grains were made during a period of roughly thirty years, with the majority after 1820.

The circumstances surrounding the illustrations of the orchid *Pterostylis Banksii* which Wodehouse has thought might bear upon the dating of all the drawings therefore need re-examination. To explain the situation it is necessary to quote the words of Wodehouse[2].

"Besides these unpublished pollen figures some of Bauer's published drawings of plants are accompanied by figures of their pollen grains. For example, the *Curtis Botanical Magazine* for 1832 carries, as No. 3172, an illustration by Bauer of an orchid, the large-leaved pterostylis (*Pterostylis Banksii*). It consists of a beautiful coloured picture of the whole plant, an enlarged flower, enlarged dissections, and a group of seven pollen grains, six in water and expanded and the seventh apparently dry and in air, consequently not expanded. These grains he found quite different from those of other orchidaceous plants. Of them he says:

"'I have now, on the second of May, examined the pollen grains with Ploessel's grand microscope, and to my great surprise, have found a total deviation from those of all the hundreds of specimens of orchidaceous plants I have yet investigated. These grains in their ordinary form consist of three- or four-celled corpuscles. . . . This I consider an important circumstance, and could not be detected by botanists possessed only of a glass of moderate power.'

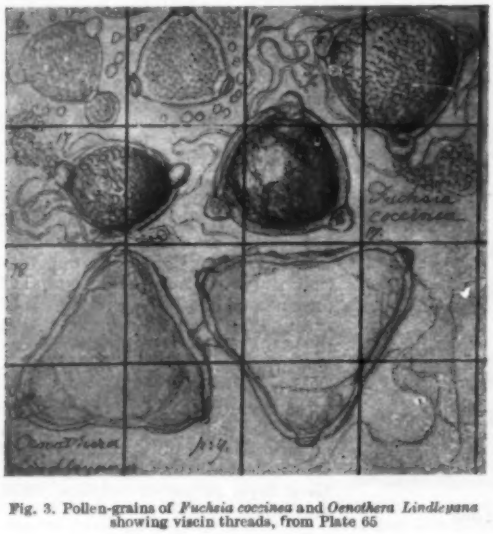

Fig. 3. Pollen-grains of *Fuchsia coccinea* and *Oenothera Lindleyana* showing viscin threads, from Plate 65

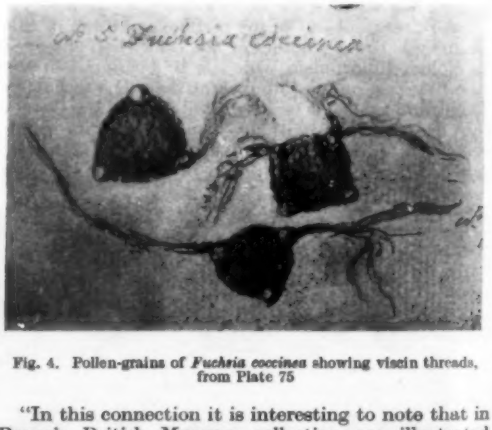

Fig. 4. Pollen-grains of *Fuchsia coccinea* showing viscin threads, from Plate 75

"In this connection it is interesting to note that in Bauer's British Museum collection are illustrated grains of 15 species of Orchidaceæ and that, of these, all except one (*Epipactis pallens**) are represented as four- or occasionally three-celled. So one is at a loss to explain his surprise at finding the grains of pterostylis to be three- or four-celled, unless the figures in the British Museum collection were all drawn subsequently to that of pterostylis, which would require the entire collection to have been done during the last eight years of Bauer's life, which seems improbable. It is true, however, that his figures of the grains of *Pterostylis* do not resemble those of any

* Now called *Cephalanthera grandiflora* Bab.

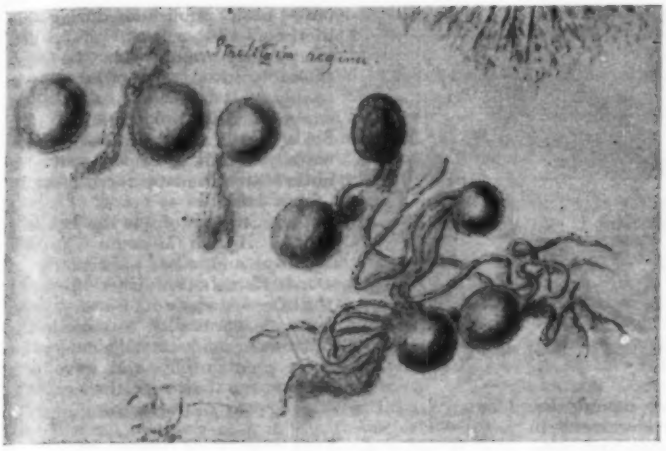

Fig. 5. Pollen-grains of *Strelitzia regina* with interweaving chains of cells, from Plate 72

other orchidaceous plants, nor do they answer his description."

There is a simple explanation for this confusion.

It need not be wondered that Bauer's drawing of the *Pterostylis* pollen does not agree with the description of the grains as consisting of "three- or four-celled corpuscles"—because he never intended to convey that impression. Careful reading of Bauer's quoted words will show that he was referring to the pollen of the "hundreds of specimens" which he had previously investigated as being three- or four-celled and not the *Pterostylis* grains which showed "a total deviation" from this condition.

In a drawing in the British Museum collection (Plate 61), Bauer has shown a ball of grains of *Pterostylis nutans* in addition to the *one-celled* grains of which it is composed. These high-power views of the individual grains show the same pattern of depressed circular areas as on the individual grains in the illustration of the related species in the *Botanical Magazine*. A drawing of *Oncydium* grains on the same plate is dated March 14, 1834.

If the literature of orchidology be consulted it will be seen that Bauer's drawings, which are, as usual, ahead of a general understanding of the significance of what they portray, depict a single-celled condition in *Pterostylis* with complete justification. This genus belongs to Lindley's[5] tribe Arethuseæ, which also includes, among others, the genera *Cephalanthera*, *Pogonia* and *Vanilla*. The pollen of each of these genera is characteristically friable. Darwin[6] emphasizes that the grains of *Vanilla* are single-celled. The pollination-mechanisms described by Cheeseman and Hemsley[7] for *Pterostylis Banksii* and by Godfery[8,9] for species of *Cephalanthera* agree in that smearing of the body of the pollinating insect with the viscid secretion of the stigma is necessary before the pollinia can be picked up. Godfery[8,9] agrees with Darwin[6] that the grains of *Cephalanthera* are tied together by a few weak elastic threads, but are not cemented together to form compound pollen-grains (tetrads) as in most of the Monandræ. Darwin's account of *Cephalanthera* contains a footnote (ref. 6, p. 80) which reads: "The separation of the grains was observed, and is represented, by Bauer in the plate published by Lindley in his magnificent 'Illustrations of Orchidaceous Plants' ". The reference quoted would be more correctly attributed to Bauer himself, for only the notes and prefatory remarks were made by John Lindley. The parts of the book were published between 1830 and 1838. There is not the slightest doubt that Bauer's reputation for accuracy remains inviolate, and that an apparent inconsistency in the dating of his unpublished drawings now disappears.

In view of the fact that the majority of the drawings in the collection at the British Museum were made before 1836, it is most remarkable how many features have been accurately transcribed by Bauer but for which he has not been given credit because his work was not published.

On several occasions, Bauer has drawn perfectly good pollen-tubes emerging from the swollen grains (for example, Plate 80, *Kæmpferia Roscœana*, shown in Fig. 2), and Wodehouse[2] tells us (from other evidence) that Bauer actually discovered and illustrated the germination of the pollinia of *Asclepias* in 1805. Amici is usually credited with being the first to observe the pollen-tube in 1823 (although it was not until 1830 that he followed its path from the stigma to the ovule in a species of *Portulara*, and it was 1846 when he indicated clearly the part it plays in the stimulation to development of the embryo).

The viscin threads which entangle the pollen-grains of members of the Onagraceæ and Ericaceæ are shown quite accurately and, in some cases (for

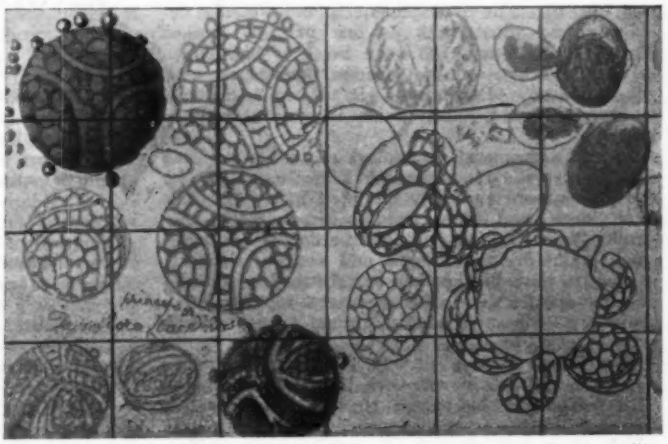

Fig. 6. Pollen-grains of *Passiflora princeps* (or *racemosa*, top left), *P. vespertina* (bottom left) and 'hybrid' (right), from Plate 64. Bauer's labelling is too faint to show clearly in reproduction

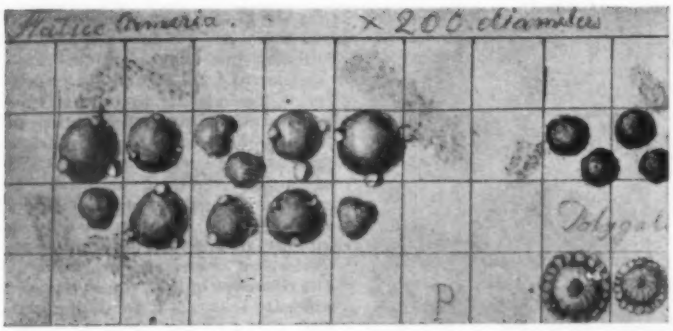

Fig. 7. Pollen-grains of *Armeria maritima* mounted in water; bad pollen unswollen, from Plate 70

example, *Fuchsia*, Figs. 3 and 4), the records are certainly the first for the genus. The discoverer of viscin threads appears to be Rafn[10], who saw them in 1796 linking grains of *Impatiens balsamina*; Link[11] showed in 1807 that they were more distinct in *Oenothera* (see also Bauer's representations in Figs. 1 and 3). More striking than the viscin threads, however, are Bauer's illustrations of the pollen of *Strelitzia* which clearly show the cellular chains weaving among the pollen-grains and derived from the walls of the anthers. They were believed to have been seen first by Palla[12], who published an account of them in 1891 and realized their significance in causing the pollen to cohere and facilitate pollination by birds. Bauer, however, shows them in two separate drawings (Plates 72 and 77, reproduced in Figs. 5 and 1, respectively). It is surprising that Wodehouse[2] does not list the craneflowers among the genera, representatives of which have been drawn by Bauer, for *Strelitzia regina* and *S. Augusta* are both depicted. It was during the period in which the drawings collected here were made that Bauer[13] published his incomparable water-colours of flowering shoots of *Strelitzia*.

For the experimental taxonomist, the most interesting illustration is that on Plate 64 where, between drawings of the very elaborately ornamented grains of *Passiflora princeps* (or *racemosa*) and *P. vespertina*, are shown very disorganized grains labelled "Hybrid" (see Fig. 6). The arrangement is undoubtedly deliberate and must rank as one of the earliest illustrations (if not the very first) of bad pollen in a hybrid between two species themselves with good pollen. Dutrochet[14] is known to have observed aborted pollen-grains in *Prunus* hybrids in 1832.

In the drawing of the pollen of *Statice Armeria* (*Armeria maritima*) contained in Plate 70 (see Fig. 7), the grains were evidently mounted in water. The four large and three medium-sized grains are swollen and bursting through the colpæ, but three small grains are not swollen and not bursting. It is known that bad pollen is produced sometimes in this species, and this accurate representation shows that the small empty grains do not absorb water.

Wodehouse (ref. 2, p. 32) has summed up his notes on Bauer's work with the comment that "He recognised the extent to which family likenesses are borne by pollen-grains and other points which were not cleared up until nearly half a century later. I believe that if Bauer's work could have been published during his lifetime, the science of pollen morphology would now be considerably in advance of what it is to-day." It is not unreasonable to suppose that progress in other fields would also have been accelerated, and it is hoped that this note will stimulate further study of his work.

I am very grateful to the Trustees of the British Museum (Natural History) and, also, particularly to Dr. J. Ramsbottom, then keeper of the Department of Botany, who gave me permission to consult the drawings, made arrangements for their photography and gave permission for their reproduction.

[1] Blunt, W., and Stearn, E. T., "The Art of Botanical Illustration" (London, 1950).
[2] Wodehouse, R. P., "Pollen Grains: Their Structure, Identification and Significance in Science and Medicine" (New York and London, 1935).
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[9] Godfery, M. J., "Monograph and Iconograph of Native British Orchidaceæ". Plates by Miss Hilda M. Godfery. (Cambridge, 1933.)
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[12] Palla, E., *Ber. d. Deutsch. Bot. Gesellsch.*, **9**, 85 (1891).
[13] Bauer, F. A., *Strelitzia* depicta; or coloured figures of the known species of the genus *Strelitzia* from the drawings in the Banksian Library (London, 1818). (The originals are now bound with Vol. VI (Monocots.) of Bauer's drawings of Kew Garden plants and are housed in the Botanical Library of the British Museum (Natural History).)
[14] Dutrochet, R. J. H., *Gard. Mag.*, **8**, 500 (1832).

THE EIGHTEENTH-CENTURY REVOLUTION IN CHEMISTRY*

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ALTHOUGH the isolation and recognition of different kinds of 'air' (or gases, as they were later called) by Black, Cavendish and Priestley played a great part in the eighteenth-century revolution in chemistry, that great change, leading to the foundation of modern chemistry, was brought about through researches on the problems of combustion, the calcination of metals and respiration.

Current theory, when the century opened, regarded combustion and calcination as processes in which phlogiston, a common constituent inflammable principle of all combustibles, including metals, was released from combustibles and metals. A similar explanation was given for respiration.

The first historically significant advance was made by Black in 1755 when he differentiated an 'air' chemically from common air; he called it "fixed

* Based on three lectures given at the Royal Institution on January 23 and 30, and February 6.

air" and showed it to be present in the mild, but not in the caustic, alkalis. Later he proved that it was produced in respiration, fermentation and the combustion of charcoal. In 1766, Cavendish distinguished another 'air', namely, "inflammable air" (hydrogen), obtained by the action of acids on metals. Black had, in fact, already pointed out that this 'air' was different from 'fixed air'. For a long time gases, as they were discovered one after another, were regarded as different kinds of air, like common air though changed in properties, but still essentially air.

From 1772 onwards the remarkable experimenter, Priestley, isolated seven further 'airs': "nitrous air" (nitric oxide), "marine acid air" (hydrogen chloride), "alkaline air" (ammonia), "vitriolic acid air" (sulphur dioxide), "diminished nitrous air" (nitrous oxide), "nitrous vapour" (nitrogen dioxide) and, most importantly for the advance of chemical theory, "dephlogisticated air" (oxygen). The last he obtained by heating mercury calx in the focus of a burning lens on August 1, 1774; he found that it was insoluble in water and that it greatly enhanced the burning of a candle-flame. He obtained it also from red lead.

Almost immediately after his isolation of this new 'air', Priestley left England to accompany his patron, Lord Shelburne, on a Continental tour. He was in Paris in October 1774, and told Lavoisier and other French chemists of the new 'air' that he had obtained two months previously. After his return to England in November 1774, Priestley found (March 1775) that this 'air' was respirable and much better than common air both for respiration and combustion. "As I think," he wrote, "I have sufficiently proved, that the fitness of air for respiration depends upon its capacity to receive the *phlogiston* exhaled from the lungs, this species may not improperly be called, *dephlogisticated air*."

Returning to Priestley's meeting with Lavoisier in October 1774, we know that, long before this date, Lavoisier had studied both combustion and respiration. His laboratory note-books show that he had experimented on the combustion of phosphorus on September 10, 1772, to find out whether or not it absorbed air in burning, but the entry does not give the result. Some weeks later, on October 20, he deposited a note with the secretary of the Paris Academy of Sciences asserting that phosphorus on burning combined with a very large amount of air and thereby increased in weight. On November 1 following, he deposited a sealed note at the Academy, stating that both sulphur and phosphorus combined with air on burning and increased in weight, and that the gain in weight of metals on calcination was due to the same cause, while, in the reduction of calces with charcoal, a large volume of air was liberated.

Some months later, on February 20, 1773, Lavoisier drew up a long memorandum in his laboratory note-book, envisaging a long series of experiments on the air set free from substances in every kind of chemical change, a series which he foresaw as "destined to bring about a revolution in physics and in chemistry". The first results of his work were published early in 1774 in his "Opuscules physiques et chymiques". Although he had here clearly grasped the idea that metals on calcination combined with 'air', his observation, that the 'air' that was evolved on the reduction of a calx with charcoal was 'fixed air', led him to suppose that it was this species that combined with the metals on calcination. He was frequently confused and uncertain at this time: sometimes he thought that the metals combined with common air, and at others he considered that they combined with an 'elastic fluid' contained in common air. Experiments on the burning of phosphorus gave a maximum reduction of one-fifth of the volume of air exposed, by combination of the phosphorus either with air or "some other elastic fluid contained in it".

On April 14, 1774, he submitted a memoir (read on November 12, 1774) to the Academy on the calcination of lead and tin in sealed vessels. The sealed vessels, weighed before and after heating, showed no change in weight, but, when the seals were broken, air was heard to rush in. When the vessels were re-weighed after the admission of air, a gain in weight was observed, he reported, in every instance exactly equal to the gain in weight detected in the metal when removed from the vessel and weighed separately. The gain in weight of the metal he ascribed to combination with the 'fixable' part of the air, which suggests strongly that he was still thinking in terms of Black's 'fixed air'. An account of this work was published during the next month, December, in Rozier's *Observations sur la Physique*. (The publication of the annual volume of *Mémoires* of the Academy was usually some years in arrears, and the opportunity of preliminary publication in Rozier's journal was often taken.)

A fortnight or so before the reading of this memoir there occurred the meeting with Priestley, at which Lavoisier was informed of the new 'air' isolated on August 1, 1774. In March 1775, Lavoisier, as his note-book shows, prepared Priestley's new 'air' and confirmed its property of enhancing the brilliance of a candle-flame; but he made a further observation, also important in his researches, namely, that it did not precipitate lime-water and therefore that it was not 'fixed air'. The immediate result was the reading to the Academy on April 26, 1775, of another memoir, which also, like its forerunner, was printed almost at once in Rozier's journal (May 1775); in this memoir Lavoisier described the production of 'air' by heating calx of mercury, and stated that the product was insoluble in water, did not precipitate lime-water or combine with caustic alkalis or render them mild, was diminished by 'nitrous air' (nitric oxide), could be used to calcine metals, did not asphyxiate animals or extinguish a lighted candle but enlarged its flame in a remarkable way—in short, it had none of the properties of 'fixed air'. Lavoisier concluded that what combined with the metals on calcination was the purest part of the air, not, it should be noted, a particular constituent of the air, but the pure air itself.

These two memoirs afterwards appeared in the annual volumes of *Mémoires* of the Academy for 1774 and 1775; but, as the publication of both volumes was delayed until 1778, the two memoirs were revised, the former being returned to the Academy after revision on May 10, 1777, and the latter being read in its new form on August 8, 1778.

In its revised form the memoir of 1774 now stated that it was a part of the air that combined with the metals in calcination, while another part did not so combine; and to the former Lavoisier gave the name "salubrious air", while the latter he described as a *mofette*, an asphyxiant, incapable of supporting combustion or respiration, the common air consisting of these two very different 'elastic fluids', the former a little heavier than the latter. In the recension of the

memoir of 1775, the part of the air which was active in combustion, respiration and in calcination was re-named "eminently respirable air", and 'fixed air' was described as a compound of charcoal and 'eminently respirable air', because charcoal, when heated with calx of mercury, completely disappeared and only mercury and 'fixed air' remained.

The new theory of combustion, respiration and calcination thus dates from 1777: later Lavoisier gave to "eminently respirable air" the name 'oxygen' or acidifying principle or element, supposing it to be a constituent of all acids.

Lavoisier's views met, however, with little or no acceptance. Until 1783, he did not openly criticize the phlogiston theory, restricting himself to showing that his explanations were more in accordance with the facts; but in 1783 he submitted a memoir (published in 1786) to the Academy criticizing the phlogiston theory in detail. There was, however, an outstanding difficulty, inexplicable in terms of his theory, but readily explicable in terms of phlogiston, namely, the production of 'inflammable air' when a metal was dissolved in acid. The phlogistic explanation was simple: a metal was composed of a calx united with phlogiston, and, when the metal was dissolved in acid, its calx combined with the acid to form a salt, while its phlogiston, thus set free, appeared in the form of 'inflammable air', which some chemists regarded as phlogiston itself. As for Lavoisier, who looked upon the action between a metal and an acid as a reaction between a metal and the compound of a non-metal with oxygen (such were the acids, in his view), he could obviously offer no explanation of the production of 'inflammable air' in this change.

The communication by Blagden to Lavoisier in Paris, in June 1783, of the results of Cavendish's as yet unpublished experiments, in which, by the combustion of 'inflammable air' either in common air or in 'dephlogisticated air', he had obtained water as the product, solved this difficulty. On June 24 of that year, in the presence of Blagden and others, Lavoisier made a rough qualitative verification of Cavendish's observation and reported the result next day to the Academy in the names of Laplace and himself. On November 12, 1783, he read a memoir to the Academy on further similar experiments, concluding that water was a compound of the two airs, namely, 'inflammable air' and 'dephlogisticated air'. The memoir was published next month in Rozier's journal and afterwards (1784) in the Academy's *Mémoires* for 1781. Cavendish had made his experiments in 1781 and had delayed publication of his paper until 1784, as he had in the meantime turned aside to solve the composition of the 'nitrous' (nitric) acid that had fortuitously appeared when he used 'dephlogisticated air' instead of common air. Cavendish's explanation was that 'dephlogisticated air' was dephlogisticated water and that 'inflammable air' was phlogisticated water, and that, by the action of the electric spark (used to explode the mixture), the 'airs' were condensed into water. It was widely believed at that time that 'airs' contained water. We may represent Cavendish's explanation thus:

'dephlogisticated air' + 'inflammable air' → (water − phlogiston) + (water + phlogiston) → water.

In Cavendish's view, therefore, the water was condensed from both airs, in each of which it was previously present as a component. In Lavoisier's view, water was a compound of the two airs. He supported his explanation by showing that iron filings decomposed water, giving 'inflammable air' and calx of iron, the latter being produced by the combination with the iron of the 'dephlogisticated air' set free from the water. Other verifications followed. Cavendish had first shown that the product of the combustion of 'inflammable air' was water; Lavoisier first gave the accepted explanation of the composition of water.

Later, in collaboration with others, Lavoisier in the "Méthode de Nomenclature chimique" (1787) set out the system of our modern chemical nomenclature, in which the names of substances indicate their chemical composition; and in 1789 he published his classic "Traité élémentaire de Chimie", expounding his new system of chemistry and containing, among other matters, the first table of the chemical elements (defined as substances that could not be decomposed into any simpler substances) and an assertion of the principle that matter is conserved in chemical change. The publication of this great book, which is comparable historically with Newton's "Principia", marked the passing of the older chemistry and the foundation of the modern science.

NEW FELLOWS OF THE ROYAL SOCIETY

At the meeting of the Royal Society held on March 15, the following were elected to the fellowship:

Dr. C. S. Beals, Dominion Astronomer, Ottawa; distinguished for his contributions to observational astrophysics, including particularly the study and interpretation of the broadened emission lines in stars with extended atmospheres and of interstellar lines.

Brigadier J. S. K. Boyd, director, Wellcome Laboratories of Tropical Medicine, London; distinguished for important contributions to bacteriology and immunology; his researches on the dysentery bacilli, the typhus fevers and tetanus led to great improvements in methods of diagnosis and control measures.

Dr. D. G. Catcheside, reader in plant cytogenetics, University of Cambridge; distinguished for his researches on the cytology and inheritance of plants and animals.

Dr. A. H. Cook, assistant director, Brewing Industry Research Foundation, London; distinguished for his researches in organic chemistry, particularly in relation to fungal antibiotics and the synthesis of heterocyclic compounds.

Dr. S. J. Folley, head of the Department of Physiology, National Institute for Research in Dairying; distinguished for his researches into the physiology and biochemistry of lactation, and particularly the influence of hormones on milk secretion.

Prof. H. Fröhlich, professor of theoretical physics, University of Liverpool; distinguished for his application of quantum theory to the physics of the solid state, including particularly the properties

of insulators and the interpretation of superconductivity; he has also made important contributions to the theory of atomic nuclei.

Dr. Geoffrey Gee, director, British Rubber Producers Research Association; distinguished for his work on the properties of substances of very high molecular weight, especially rubber and rubber-like substances.

Prof. H. A. Heilbronn, professor of mathematics, University of Bristol, distinguished for his discoveries in the analytic theory of numbers and, in particular, for his work on the class-number of quadratic fields.

Dr. G. Herzberg, director, Division of Physics, National Research Council, Ottawa; distinguished for his contributions to experimental and theoretical physics and chemistry, in particular for his work on molecular and atomic spectra.

Dr. J. B. Hutchinson, director, Central Cotton Research Station, Namulonge, Uganda; distinguished for his genetical studies of the cotton plant, which have led to notable advances in the classification of this genus, and to the theory of the evolution of its species.

Dr. H. R. Ing, reader in pharmacological chemistry, University of Oxford; distinguished for his investigations on the chemistry of drugs and the chemical aspects of drug action.

Dr. David Lack, director, Edward Grey Institute of Field Ornithology, Oxford; distinguished for his studies on the behaviour and evolution of birds, especially the formation of species and races of the finches of the Galapagos Islands.

Dr. T. R. R. Mann, member of the staff of the Agricultural Research Council; a biochemist distinguished for his researches on carbohydrate and phosphorus metabolism of muscle, moulds and mammalian seminal fluid, and for his studies on metalloprotein enzymes.

Dr. K. A. G. Mendelssohn, University demonstrator, University of Oxford; distinguished for his work in experimental physics, especially for his investigations on the properties of liquid helium and of the superconducting state.

Dr. A. Neuberger, biochemist, National Institute for Medical Research, London; distinguished for his researches on the biochemistry of amino-acids and proteins.

Dr. L. B. Pfeil, director of research, Mond Nickel Co., Ltd.; distinguished for his contributions to metallurgical research on ferrous and non-ferrous metals.

Dr. J. A. Prescott, director, Waite Agricultural Research Institute, Adelaide; distinguished for his investigations on the soil types of Australia, their geographical distribution and relation to climate and vegetation.

Prof. M. H. L. Pryce, Wykeham professor of physics, University of Oxford, distinguished for his work in theoretical physics, in particular quantum mechanics and quantum electrodynamics, and for his contributions to the knowledge of the properties of the solid state at low temperatures.

Dr. W. J. Pugh, director, Geological Survey of Great Britain and the Museum of Practical Geology, London; distinguished for his researches on the Ordovician and Silurian rocks of Wales.

J. A. Ratcliffe, reader in physics, University of Cambridge; distinguished for his contributions to the development of the scientific basis for radio communications.

Prof. T. A. Stephenson, professor of zoology, University College, Aberystwyth; distinguished for his researches on marine biology, especially on the growth and reproduction of corals and the distribution of animals and plants on the sea-shore.

Dr. W. H. Thorpe, lecturer in entomology, University of Cambridge; distinguished for his researches on insect physiology and animal behaviour.

Dr. P. J. du Toit, president of the Council for Scientific and Industrial Research, South Africa, formerly director of the South African Veterinary Research Institute, Onderstepoort; distinguished for his contributions to the study of the diseases of animals, especially of domestic cattle, and particularly those due to soil deficiencies and to infections transmitted by ticks.

A. M. Turing, assistant director, Computing Machine Laboratory, University of Manchester; distinguished for his contributions to mathematical logic and, in particular, for his work on computable numbers.

Prof. A. R. J. P. Ubbelohde, professor of chemistry, Queen's University, Belfast; distinguished for his work in physical chemistry with special reference to structural and thermodynamic questions and reaction mechanism.

NEWS and VIEWS

Mining at King's College, Newcastle: Prof. Granville Poole

Prof. Granville Poole, who is shortly retiring from the Milburn chair of mining at King's College, Newcastle, was appointed to this post in October 1923 in succession to Prof. Henry Louis. Before going to King's—or Armstrong College as it was then called—he had occupied the chair of mining in the University of Leeds during 1920–23. Previously he had seen extensive service in various posts in the Mines Department at the Home Office and had gained a wide experience in matters relating to spontaneous combustion in coal mines. His interest in them has never flagged, and frequently he has been called upon to apply his specialized knowledge to the investigation of colliery explosions. He was also supervisor of the Northern Coke Research Committee and the Fuel Survey Committee for Northumberland and Durham. In 1924 Prof. Granville Poole started the Armstrong College Mining Society, becoming its first president, and has continued to hold this office ever since. In 1946 he inaugurated the *King's College Mining Bulletin*, a publication which has a wide circulation to those interested both at home and abroad. He is the author of a treatise considered as a standard work on haulage and winding, and has frequently been consulted on this and other aspects of the mechanization of the coal mines in the North. He is the present president of the North of England Institute of Mining and Mechanical Engineers, and a member of the Council of the Institution of Mining Engineers.

Mr. E. L. J. Potts

Mr. Edward L. J. Potts, who has been appointed to succeed Prof. Granville Poole, comes from a mining family, being one of four sons, three of whom graduated in mining at King's College, Newcastle. After taking first-class honours, he conducted research into ventilation problems and was awarded the M.Sc. He possesses the mine surveyor's and first-class manager's certificate of competency and was appointed lecturer in mining in 1940, and reader in 1946, at King's College. In addition to practical experience in Great Britain, he has studied mining methods abroad and is at present engaged with Prof. Fritzsche, of Aachen, in compiling a treatise on "Horizon Mining" sponsored by the National Coal Board. Mr. Potts has carried out a considerable amount of research and has many publications. His research includes the distribution of stress around underground excavations, using photo-elastic methods; the investigation of air-flow conditions in underground roadways and in mine fan installations; the development of an original design of a circular fluorescent-lighting unit for face and roadway lighting, and the application of anodized aluminium reflectors; and the design and operation of a fine-coal washing system incorporating a paraboloid cone equipped with jets. Mr. Potts was technical adviser to the Northumberland coal owners at Stage II of the Valuation of Northumberland Collieries under the Coal Mines Nationalization Act. He has been appointed mining adviser to the Peterlee Development Corporation, and is conducting subsidence surveys and advising on mining subsidence in relation to the development of a master plan for the new town.

International Polarographic Congress in Prague

A meeting of some four hundred workers interested in polarography was held in Prague during February 4–8. Visitors from Poland, Hungary, Roumania and Bulgaria were present. The congress was organized by the Centre of Research and Technical Development in Prague, under the presidency of Prof. J. Heyrovský, director of the Central Institute of Polarography, with Prof. R. Brdička, director of the Physico-chemical Institute of the Charles University, Prague, as vice-president. An evening meeting for visitors, held in the old palace of Sylva Taroucca, preceded the opening of the Congress, which was inaugurated in the large theatre of the Purkyně Medical Institute on February 5 by the Minister of Planning, Dr. J. Dolanský, and director of the Centre of Research and Technical Development, Prof. J. Fukátko. Dr. Dolanský spoke on the cardinal tasks of science in building up socialism, and Prof. Fukátko on the role of planning in scientific research. Prof. J. Heyrovský then gave a review entitled "Fundamentals of Polarography". The proceedings of the Congress were divided into eight surveys, each of about an hour's duration, in which modern developments of polarography were summarized, and the discussion of papers submitted to the Congress. The following surveys were given: Vl. Majer, "Inorganic Analysis"; Vl. Hanuš, "Polarography of Organic Compounds"; P. Zuman, "Organic Analysis"; F. Šantavý, "Polarography in Biochemistry and Medicine"; J. Forejt, "Instruments for Oscillographic Polarography"; J. Heyrovský, "Applications of Oscillographic Polarography"; R. Brdička, "Kinetics of Electrode Processes in Polarography". Fifty-five communications were presented. Reports on the communications and discussions will be published in full in three volumes, of which the first will also contain contributions from abroad not communicated at the Congress, in English, French and German, the second a full bibliography of polarographic papers from 1922 to 1950, and the third actual reports of the meetings. Single volumes, which will appear about in April, will be sold to non-members of the Congress.

National Central Library: Annual Report for 1949–50

The thirty-fourth annual report of the executive committee of the National Central Library, covering the year ending February 28, 1950 (pp. 30; London: National Central Library, 1950), refers to an increase in the Treasury grant-in-aid from £19,000 to £22,500, including a sum of £1,000 to offset the second stage in the discontinuance of the contribution from the Carnegie United Kingdom Trust. A satisfactory response was received to the attempt made in the financial year 1946–47 to increase the sum obtained from libraries of research, commercial and industrial organizations not participating in regional systems but making substantial calls on the Library's services. Total issues from or through the Library were 96,552 volumes, an increase of nearly three per cent on 1948–49; but the number of volumes issued to university libraries increased by 22·42 per cent to 12,786, while 17,234 volumes were lent by the university libraries to other libraries. Volumes issued to the special outlier libraries, which now number 207, increased from 6,732 in 1948–49 to 7,404, and 17,574 books were lent by these outlier libraries; books issued to libraries of government departments, research and industrial organizations increased from 9,405 to 11,903 volumes. Some 607 libraries are now co-operating in the regional systems, and they lent 164,152 volumes to other libraries in their own systems and 21,423 volumes to libraries in other regional systems and to non-regional libraries through the National Central Library. There was a striking development in international loans, 994 books being lent to twenty-three countries and 420 borrowed from nineteen countries. The activities of the British National Book Centre in arranging for the exchange of 'unwanted' books and periodicals between libraries of different types in Great Britain, between libraries in Britain and those in the Dominions and Colonies, and between British and foreign libraries, continued to expand.

"Agronomia Angolana"

The third number of "Agronomia Angolana", published annually by the Serviços de Agricultura at Luanda, Portuguese West Africa (C.P. 1233), was issued in 1950, previous numbers being those for 1948 and 1949 (No. 1, pp. 204; No. 2, pp. 263; No. 3, pp. 176; 20 angolares each). Its aim, as stated by the editor, is the dissemination of information on agricultural investigations in progress at research stations in the Colony of Angola and elsewhere, and to promote exchange of ideas and of current knowledge. Certain articles of a general character are included, such as those describing the scope and programmes of work at individual agricultural experimental stations, and developments in the Colony's agriculture. Original papers are published on a variety of topics, including methods adopted in plant breeding, aspects of fruit growing,

regional pedology and meteorology, organic manuring, mechanization, forestry, selective weed-killers, and economic and agricultural botany. The publication is designed mainly for circulation to scientific institutions; its subject-matter and format are of a high standard, and most papers have reasonably good summaries in French and English, but many of them lack bibliographical references. To cater for growers, "Agronomia Angolana" has established an extension service which will produce bulletins and leaflets for distribution to growers, incorporating the relevant information in a more popular form.

Collection of Bygone Agricultural Implements

THE collecting of early agricultural implements is an imperative necessity at the present time if any of the fast-disappearing types are to be preserved for posterity. Many museums are engaged in this important task, and the Gloucester Folk Museum, housed in Bishop Hooper's Lodging, in addition to collecting and displaying such material, has issued a handy and authoritative guide to its agricultural collections, entitled "Guide to the Collection of Bygone Agricultural Implements" (pp. 20+4 plates; Gloucester: Folk Museum, 1950; 9*d*.). The material is appropriately grouped under the operations of ploughing, sowing and cultivation, haymaking and harvesting, ricking, thatching and threshing, with an added section for certain miscellaneous farm implements. Each section is prefaced by some useful general remarks on the subject, written by J. N. Taylor, the curator.

Archives of Biochemistry and Biophysics

BEGINNING with Vol. 31, No. 1 (March 1951), the title of *Archives of Biochemistry* has been altered to *Archives of Biochemistry and Biophysics*. This change reflects the ever-increasing use of physical methods in biochemistry and is consequent upon the recent decision of the editors to consider, in addition to established biochemical topics, communications in the fields of virus research, radiation effects on living matter, macromolecular biology and chemistry, studies of the application of radioactive indicators, and the physics of biological systems. The editorial board has also been enlarged and includes the following new members: Drs. E. Newton Harvey, E. C. Pollard and R. W. G. Wyckoff.

Science in General Education

THE Harvard Summer School of Arts, Sciences and Education is organizing a conference on "Science in General Education" to be held during July 9–11 at Harvard University, Cambridge, Mass. A series of three evening meetings, open to the public, are being arranged on "Science and Society", "Science and Philosophy" and "Science and History", which will be directed by Dr. K. T. Compton (Massachusetts Institute of Technology), Prof. P. Le Corbeiller (Harvard) and Prof. I. Bernard Cohen (Harvard), respectively. Each meeting will consist of two prepared papers, thirty to forty minutes in length, followed by a discussion by two commentators, of about fifteen minutes each. On the afternoon following each meeting, a number of invited guests will meet privately for a further discussion, based on the talks of the previous day. These guests, who will number about sixty to eighty, will include leading figures in contemporary science, both pure and applied, some government representatives (both military and non-military) connected with science, a number of educational leaders and teachers, and some scholars or specialists; a few will be from Europe, and from Canada and Mexico. These private discussions will thus provide an opportunity for bringing together a number of different groups who, in one way or another, are concerned with science or with its effects on human affairs. Correspondence referring to the School should be sent to the Director, Harvard University Summer School of Arts and Sciences and of Education, 2 Weld Hall, Cambridge 38, Mass.

University of London

MR. M. B. DONALD has been appointed to the Ramsay Memorial chair of chemical engineering tenable at University College from October 1. The degree of D.Sc. has been conferred on the following: Mr. C. B. Allsopp, appointed teacher at Guy's Hospital Medical School; Mr. Eugen Glueckauf, Imperial College of Science and Technology; Mr. W. C. J. Ross, Imperial College of Science and Technology.

Engineering-Apprentice Scholarships for British Commonwealth Graduates

THE BRUSH ABOE Group of companies has recently instituted a new scholarship scheme whereby honours graduates in engineering from overseas countries of the British Commonwealth can undertake a two-year practical apprenticeship, studying the products and methods of the Group. The first year will provide general instruction in basic manufacturing processes, after which more specialized topics will be studied. The factories concerned are: The Brush Electrical Engineering Co., Ltd., Loughborough, Leics.; Mirrlees, Bickerton and Day, Ltd., near Stockport, Cheshire; J. and H. McLaren, Ltd., Leeds 10; Petters, Ltd., Staines, Middx.; Henry Meadows, Ltd., Fallings Park, Wolverhampton; and the National Gas and Oil Engine Co., Ltd., Ashton-under-Lyne. Apprentices will be provided with a free return passage and will be paid the standard wage-rate (at present £6 9*s*. 6*d*. a week). Further details can be obtained from BRUSH ABOE Group Services, Ltd., of Duke's Court, Duke Street, London, S.W.1.

Announcements

MR. P. A. WELLS, director of education to the International Wool Secretariat, has been appointed deputy secretary and secretary-elect of the Royal Sanitary Institute.

THE annual conference of the Textile Institute will be held this year in Brighton during May 21–25. Thirty-six papers will be read, the general theme of the conference being "Textiles: their Past, Present and Future". Further details can be obtained from the Institute at 16 St. Mary's Parsonage, Manchester 3.

DR. E. CLAR, lecturer in chemistry in the University of Glasgow, has been awarded one of the prizes offered by the Spanish Government for a paper, on the absorption spectra of aromatic hydrocarbons at low temperatures, read at the Twenty-second Congress on Industrial Chemistry.

ERRATUM. In the review of "Chemistry and Uses of Insecticides" by Dr. E. R. de Ong (*Nature*, 167, 211; Feb. 10, 1951) the price is quoted as 36*s*. net. Owing to devaluation, the price has now been raised to 54*s*. net.

PLASTICITY OF MAMMALIAN MONOSYNAPTIC REFLEXES

By Prof. J. C. ECCLES, F.R.S., and Dr. A. K. McINTYRE
Department of Physiology, University of Otago, Dunedin, New Zealand

PLASTICITY in the central nervous system, that is, the ability of individual synaptic junctions to respond to use and disuse by appropriate changes in transmissive efficacy, is frequently postulated or implied in discussions on the mechanisms underlying the phenomena of learning and memory[1,2]. Little concrete evidence has, however, been brought forward in support of this concept, possibly because of the great technical difficulties of studying quantitatively synaptic transmission in the higher levels of the nervous system, where the postulated property of plasticity may reasonably be expected to reach its fullest development. In the case of simpler spinal and brain-stem reflex-levels, some investigations have indicated a considerable measure of reflex remodelling after such procedures as nerve or muscle transposition[3]; but, on critical examination[4], the balance of evidence tends towards the view that, in mammals, functional state as well as spatial pattern remain relatively constant at such elementary reflex levels. Moreover, precise investigations of transmission in the simplest (monosynaptic) reflex arcs have not, until lately, revealed changes in functional state lasting for more than about one-hundredth of a second[5-7]. Recently, however, more enduring changes have been shown to take place in monosynaptic reflex arcs, the effectiveness of a given presynaptic volley becoming greatly enhanced for a period of several minutes after an intensive burst of repetitive firing of the same presynaptic fibres, a phenomenon that has been called post-tetanic potentiation[8,9]. It can be argued that this relatively enduring change in synaptic functional state indicates the existence of an element of plasticity even at this level of nervous function—the simplest possible reflex arc[9]. Accordingly, we have studied the effects of *disuse* on such reflex arcs, with the object of determining whether prolonged inactivity of presynaptic paths leads to a deficiency of synaptic excitatory action, a deficiency which, if reversible by activity, would strongly support the concept of plasticity at the simplest reflex-level.

Prolonged and total disuse can be most effectively secured by severing the dorsal roots just distal to their ganglia, thus retaining functional continuity between parent cell bodies and the central projections within the spinal cord of their silenced fibres. This operation was done with aseptic precautions for two or three of the dorsal roots innervating the cat's hind limb (lumbar 6 and 7 and sacral 1), great care being taken to minimize injury to the ganglia and to the subjacent ventral roots. All operations were done entirely extra-durally so that the delicate intra-dural segments of the spinal roots did not suffer damage by post-operative scarring. The roots of the other side were left intact as controls; but in some experiments they were subjected to a dummy operation, only the cutting of the dorsal roots being omitted. Afterwards the animals were exercised daily by walking in a simple treadmill, and 34–40 days post-operatively under nembutal anæsthesia the spinal cord was divided in the lower thoracic region and the reflex activity of the caudal stump was systematically investigated on both sides. Reflex responses were set up by single dorsal root volleys (maximal for the large group-I afferent fibres), and were recorded monophasically either from nerves to various limb muscles (both flexors and extensors to digits, ankle and knee) or from one or other of the isolated ventral roots. In addition, all reflex responses were observed after post-tetanic potentiation[8,9]. Every precaution was taken to enhance the significance of the comparison between the two sides: extreme care in dissection and manipulation; identical placing of recording electrodes on the corresponding nerves and roots; multiple records of each reflex so that mean values for the two sides could be compared; temporal juxtaposition (and often alternating sequence) of each series of investigations on the two sides; subsequent histological examination of the nerves and roots on the two sides.

Our experiments have given convincing evidence that the operative section greatly diminished the reflex effectiveness of dorsal root volleys. For example, a volley in the combined L_7 and S_1 roots failed to evoke a monosynaptic reflex discharge to the gastrocnemius muscle (Fig. 1*a*, *L*) in contrast to the normal control side (Fig. 1*a*, *R*). Nevertheless, quite a large monosynaptic reflex was evoked during conditioning by post-tetanic potentiation, though it was still well below the control side similarly potentiated (Figs. 1*a*, *L* and *R*). Likewise, there was merely a trace of monosynaptic discharge to the biceps-semitendinosus muscles, which was greatly potentiated (Fig. 1*b*, *L*), though only to about one-quarter of the potentiated size on the control side (lowest record, Fig. 1*b*, *R*). Later polysynaptic flexor reflex discharges are prominent in all records of Fig. 1*b*, having latent periods from 3·3 to at least 10 msec.

Figs. 1*a* and *b* illustrate the asymmetry that was observed in twenty-five series of investigations on reflex discharges into muscle nerves. Five of these experimental series resembled Fig. 1*b* in that unconditioned dorsal root volleys evoked monosynaptic reflexes that differed from the control side merely by their much smaller size (cf. Fig. 2, open circles). Only two series were exceptional, the reflex responses being not significantly different on the two sides. Relatively larger reflexes were never evoked by volleys in the operatively sectioned roots. In eleven series of investigations, we have recorded the reflex responses from a single isolated ventral root corresponding segmentally to the stimulated dorsal root. Uniformly the monosynaptic reflexes have been much smaller for the operatively sectioned roots, being often absent, and this disparity has been maintained during post-tetanic potentiation.

The question at once arises: To what extent can reflex deficiency on the operated side be attributed to changes in the presynaptic pathways other than mere absence of the normal impulse barrage? Two such possible causes have been revealed by subsequent histological examination of the appropriate dorsal roots stained with osmic acid.

First, in many experiments, there was some post-operative degeneration of fibres in the intradural path of one or other of the severed dorsal roots,

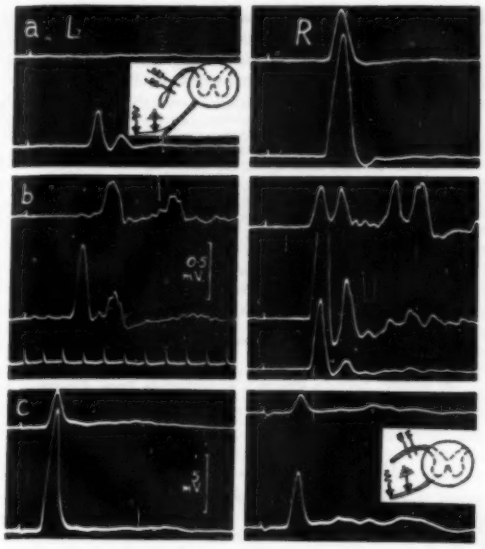

Fig. 1. Reflex discharges in one experiment in response to single dorsal root volleys maximal for group I fibres, the left and right sides being marked *L* and *R*. The left L_7 and S_1 dorsal roots had been severed just distal to the ganglion forty days previously. In (*a*) upper records show reflex discharge into gastrocnemius nerve evoked by a volley in L_7 and S_1 dorsal roots (see inset), being zero for *L*, but large in control *R*; lower records, responses after same degree of post-tetanic conditioning for *L* and *R*. Curves (*b*) are as for (*a*), but reflex discharges into the conjoint biceps-semitendinosus nerve. With unconditioned *L* there is a minute monosynaptic discharge (increased by conditioning to a large spike) and large later polysynaptic discharges of flexor reflex. Post-tetanic conditioning so greatly increased the *R* monosynaptic spike that it was deflected off the screen, and the lowest record gives the response at ¼ amplification. Note with *R* the later polysynaptic discharges of flexor reflex. (*c*) shows single volleys in L_6 dorsal root and recording from corresponding L_6 ventral root (see inset diagram). Time scale given in milliseconds for all records. Except for lowest (*b*) *R* record, the potential scale is as shown for all (*a*) and (*b*) records. Potential scale as shown for all (*c*) records. All illustrations chosen from several closely similar records

presumably the result of ganglionic injury, either at operation, or afterwards through post-operative scarring, which was often considerable in the immediate vicinity of the ganglia. However, in experiments involving operated roots in which no loss of fibres was detectable, the same reflex deficiency was observed; for example, the reflexes illustrated in Figs. 1*a* and *b*. Thus it appears unlikely that loss of dorsal root fibres in other experiments can be regarded as more than a contributory cause of the reflex disparity observed.

Secondly, even when no actual loss of fibres was detectable, those in the operated dorsal roots were slightly smaller (mean, about 90 per cent for the largest fibres) than fibres in the corresponding normal roots of the opposite side. In keeping with this, conduction velocity was about 10–15 per cent lower in the dorsal roots silenced by operation. Presumably this shrinkage is analogous to axonal shrinkage in the central stump of a regenerating nerve, and may be attributable to a diminished turgor consequent on regenerative outgrowth[10–12]. Though it seems improbable that shrinkage of this order would be entirely responsible for the usual large depression of monosynaptic reflex responses (cf. Figs. 1*a* and *b*), it is not possible directly to refute the suggestion that the synaptic knobs shrink more than the main axonal shafts from which they spring, their depressed reflex excitatory power being thus explained.

However, two observations suggest that the reflex disparity observed in these experiments carries a wider implication than if it were caused merely by shrinkage attributable to regenerative outgrowth.

The first of these observations is that the dorsal root immediately rostral to those operatively divided had a much greater reflex effectiveness than its companion on the normal side. In all five experiments where it was tested, the reflex spike discharge into the corresponding ventral root was significantly larger (from about twice upwards) than on the control side, and this difference was maintained during post-tetanic potentiation (Figs. 1*c*, *L* and *R*). This may reasonably be attributed to the development of some compensatory reaction to the operative disability. With operative section of L_7 and S_1 dorsal roots, the relative enhanced reflex discharge from L_6 dorsal root was always found in the nerves to semimembranosus (three experiments) and to biceps-semitendinosus (two experiments); but there was little or no asymmetry in the discharges to the muscles supplied by the deep peroneal nerve. With L_6 and L_7 root section the compensatory reaction was observed with L_5 dorsal roots, which gave, however, symmetrical reflexes when next but one above the operative lesion. The simplest explanation of this compensatory reaction is that the operative disability has thrown more mechanical stress on the remaining stretch receptors of any partially de-afferented group of synergic muscles. There would thereby be produced an increased monosynaptic bombardment of motoneurones through the dorsal root immediately adjacent to those severed, the increased usage giving rise to enhanced synaptic excitatory effectiveness.

The second observation relates to the possibility that an intense but brief prototype of such an effect is already known in post-tetanic potentiation[8,9]. It has been argued that this potentiation is most probably explained as a changed spatial relationship which gives more effective synaptic transmission; for example, the synaptic knobs may become larger or more closely apposed to the post-synaptic membrane[9]. With the operatively severed roots, post-tetanic potentiation has produced a remarkable increase in monosynaptic excitation (Figs. 1*a*, *L*, and 1*b*, *L*), but, in addition, preliminary observations disclosed two special features. After a standard conditioning tetanus of 6,000 volleys at 400 a second the time course of the potentiation was slower than on the control side, the summit being later (18–40 sec. as against 8–14), and the decay therefrom much more prolonged (Fig. 2). Furthermore, after the first conditioning tetanus there was an enduring increase in size of the monosynaptic reflex (Fig. 2, open circles and subsequent test shown by filled circles). It would appear that conditioning by the intense period of activity effected a partial restoration of the operative disability, as shown by the residual level of potentiation following the first conditioning tetanus (open circles beyond 400 sec. in Fig. 2). (*Note added in proof.* These preliminary results have been

fully confirmed, the residual potentiation persisting for many hours.)

Thus we are introduced to the concept that activity enhances the functional effectiveness of synapses over a much longer period than the several minutes of ordinary post-tetanic potentiation, though it must be realized that there is as yet no direct evidence to relate these two causes of enhanced function. Nevertheless, it may be postulated that disuse is a probable cause of the defective monosynaptic excitatory action of volleys in our operatively severed roots, for no impulses will have passed along those roots during the post-operative period of five weeks or so. Such an explanation implies that the normal level of synaptic activation by discharge of stretch receptors ordinarily maintains the excitatory effectiveness of the monosynaptic reflex path.

In conclusion, it can be stated that in the simplest mammalian reflex (the monosynaptic myotatic reflex) direct experimental evidence has been obtained in support of the hypothesis that usage leads to increased functional efficiency of synapses and disuse to defective function. The plasticity that has been postulated for higher nerve centres in explanation of conditioned reflexes[1,2] and of memory would appear to be an important attribute even of the synapses of the simplest reflex pathway. An opportunity is thus provided for precise systematic study of plasticity.

It has been suggested that learning processes, for example, memory and conditioned reflexes, can be attributed to specific dynamic patterns created by impulses circulating continuously in closed self-re-exciting chains of neurones[13,14]. Repetitive activity of this kind doubtless accounts for functional changes of brief duration, but raises grave difficulties when applied to enduring memories or conditioned reflexes[2,14]. The existence of plastic changes at synapses, as demonstrated in the monosynaptic reflex arc, would remove the necessity for making the improbable postulate of enduring dynamic patterns of circulating impulses, and would provide experimental evidence for an explanation based on patterned changes in synaptic efficacy, possibly of a morphological character[1,2]. Such an explanation, however, presupposes that these enduring plastic changes are initially brought about, and are susceptible to reinforcement, by barrages of impulses occurring during temporary phases of patterned re-excitatory activity.

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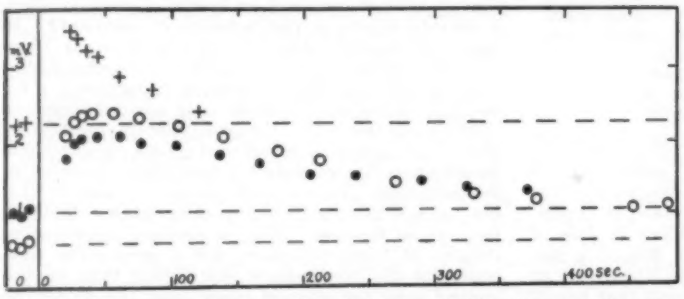

Fig. 2. Time course of post-tetanic potentiation (6,000 volleys at 400 a sec.) of monosynaptic reflex discharges into gastrocnemius nerve in response to single volleys in L_7 dorsal root. L_6, L_7 and L_8 roots on left side were severed just distally to ganglion forty days previously. Ordinates, sizes of reflex spikes; abscissæ, testing intervals in seconds after onset of conditioning tetanus. Crosses show responses on control *R* side, open circles on operated *L* side. Preconditioned spikes are plotted in same convention to left of vertical line at zero time, the horizontal broken lines showing mean spike voltages at respective control-levels. Note that to left of the zero time-line the open circles plot preconditioned spikes before any dorsal root tetanization, that is, after a complete quiescence of forty days, while afterwards the open circles give the response to the first conditioning tetanus. Filled circles show repetition of the *L* series several hours later

NATIONAL PHYSICAL LABORATORY OF INDIA

Of the eleven national laboratories planned by the Council for Scientific and Industrial Research, India, the National Physical has very appropriately been located in Delhi itself, the seat of the Union Government. Unlike some of the other national laboratories specializing in problems peculiar to particular industries and therefore of greater interest to some regions than to others, the National Physical Laboratory is concerned with basic fundamental work; further, this Laboratory is expected to provide the standards of length, mass, etc., which will be given statutory acceptance, and is therefore of peculiar importance to the State.

An account of the plans for this Laboratory appeared in *Nature* of February 8, 1947, soon after its foundation stone had been laid by Mr. Jawaharlal Nehru. The Laboratory was inaugurated by the late Sardar Vallabhbhai Patel, Deputy Prime Minister, on January 21, 1950.

The Laboratory now functions in an imposing building, carefully planned for its purpose. The architects visited leading foreign laboratories of similar character, and an assistant director spent a good deal of time making a detailed study of the National Physical Laboratory at Teddington. On the architectural side, the Delhi institution has borrowed certain features from the R.C.A. and Bell Telephone Laboratories in the United States; in its functions its two main sources of inspiration have been the National Physical Laboratory at Teddington and the National Bureau of Standards, Washington.

The Laboratory's work was originally planned in nine Divisions: (1) Weights and Measures; (2) Applied Mechanics and Materials; (3) Heat and Power; (4) Optics; (5) Electricity; (6) Electronics and Sound; (7) Building and Housing Research: (8)

Hydraulic Research; (9) Analytical Chemistry. To these nine Divisions of the original plan, a tenth has been added which concerns itself with industrial physics. Meanwhile, for building and housing research a separate national laboratory at Roorkee has been decided upon.

The National Physical Laboratory has a spacious site, about sixty-six acres in area, and is situated next to a great centre of scientific research, the Agricultural Research Institute. The National Physical Laboratory buildings already cover 150,000 sq. ft. and are not yet completed. The laboratories, workshops, library and administrative rooms were naturally given precedence. The lecture theatre is now ready and a cafeteria nearly so. Social amenities are not being neglected. The National Physical Laboratory can well feel proud of its modern and noble building, and the first impression on the considerable number of visitors that it attracts is an excellent one. The rooms in the main building are of adjustable length in steps of 6-ft. units and are air-conditioned. The *L*-shaped basement, with its larger limb 590 ft. long, serves as a store as well as a tunnel for protected services; these go to every room in the Laboratory, not disfiguring the walls and corridors and yet eliminating the necessity of having to dig in to the walls and floors when new service lines have to be laid.

Sir K. S. Krishnan, who was associated with Sir C. V. Raman's discovery of the Raman effect, is director of the Laboratory and is ably assisted by six assistant directors. Besides metrological work and work connected with the maintenance of standards, fundamental research in various sections is being carried on, including that on supersonics. The Laboratory is the only one in India equipped with an electron microscope. The Laboratory was fortunate in getting at a nominal price very valuable equipment for its excellent workshop, where it may be possible to make a large variety of instruments needed in its different sections. Surplus war-stores have been useful, and the Indian scientific liaison officer in London made an excellent selection of items from such disposal sales in Great Britain. The Laboratory is already interesting itself in applied research, and new processes for printing inks using new ingredients perfected by its workers have gone through the necessary laboratory tests, and are entering on the commercial stage in the Laboratory itself.

The inaugural ceremony was attended by leading men of science from many countries, who went to Delhi after participating in the Indian Science Congress session in Poona, and by Mr. C. Rajagopalachari (then Governor-General of the Indian Dominion), who presided, Mr. Jawaharlal Nehru, Dr. S. P. Mookerjee (at that time Minister for Industries and President of the Council for Scientific and Industrial Research), and Sardar Vallabhbhai Patel, who declared the Laboratory open. Great appreciation was expressed of the devoted work done by Sir Shanti Swarup Bhatnagar, director of the Council, and by Dr. K. N. Mathur, assistant director for planning, and there was general rejoicing over the choice of Sir K. S. Krishnan as director of the Laboratory. Speaking of Sir Shanti Bhatnagar, Mr. Nehru said that "this large programme of building the national laboratories would never have gone as far ahead as it has if Dr. Bhatnagar had not been in charge of them". He also paid tribute to Sir. K. S. Krishnan: "It will be difficult," he said, "to find a shyer and more modest man, and yet those who know him know that under that shyness and modest exterior there is a depth and profundity of learning, and it has been a particularly good fortune for us to have him as our Director".

Sir Shanti Bhatnagar, in his address, gave a history of the planning of the National Physical Laboratory since the idea was conceived in 1941, and spoke of its scope and possibilities. Both he and Sir K. S. Krishnan referred to the need for "large-scale specialized organizations for scientific research" and for "team-work". Elaborating on this aspect, Sir K. S. Krishnan observed: "It was not so long ago that we used to speak of the genius in the garret, not so much with a guilty sense of our neglect of values, but almost as though it were the proper atmosphere for genius to flourish in. A story is told of a great past president of the Royal Society that when a visitor from the Continent wished to see his laboratory, he requested him to be seated in the drawing-room and had the laboratory brought to him on a tray. Many great scientists have grown under, and lent enchantment to, this tradition, which has since been called, with some appropriateness, the 'string-and-sealing-wax tradition': Faraday, the Curies, Thomson, Rutherford and Raman. But for the majority of us the Muse of Science has become a little too sophisticated to be wooed under such simple surroundings. Large laboratories, liberal equipment, and enthusiastic teams are the least that seem to satisfy her—the more so when science has to be applied to industry, as it will be, in these Laboratories."

Dr. H. J. Bhabha, director of the Tata Institute of Fundamental Research, Bombay, also stressed this point. As a member of the Planning Committee for the Laboratory, he recalled that "the Committee endeavoured to plan the Laboratory on the most modern lines and to make its scope, design and equipment such as would place it among the best laboratories of its kind in the world to-day. It is not often in human affairs that the realization of an idea exceeds the dreams of those who planned it, but I think I would be right in saying that none of the members of the Planning Committee of this Laboratory could have fully realized what a magnificent Laboratory it would become."

Sir Robert Robinson, at the time president of the Royal Society, referred with "justifiable pride" to the achievements of the National Physical Laboratory in Britain, which was due to celebrate in a few days its fiftieth birthday, and conveyed to its new-born sister the warmest good wishes on behalf of the Council of the Royal Society and of the governing body of the National Physical Laboratory at Teddington. Greetings were conveyed also by Prof. J. D. Bernal, professor of physics in Birkbeck College, University of London, and a member of the General Board of the National Physical Laboratory, who in the course of his address observed: "Money spent on science is money saved. Science is economy. This economy, however, can only be realized if the people feel and have reason for feeling that the work of science and industry is for the common welfare and not diverted to the service of private profit and war."

Prof. P. V. Auger, speaking as director of the Natural Sciences Section of Unesco, and as professor in the Faculty of Science, University of Paris, offered the warmest congratulations on the occasion, and said of the new institution: "This is no small pearl,

but rather a big diamond like the Koh-i-Noor of the history of this country". The greetings of the scientific men of the U.S.S.R. were conveyed by Prof. W. D. Englehardt. Prof. D. E. H. Rydbeck, of the Chalmers Institute of Technology, Sweden, expressed the hope that under the scientific and spiritual leadership of Sir K. S. Krishnan the new institution would work in the spirit of Tagore and Gandhi, and show the world that "even in the times of tremendous technical and scientific developments ahead of us, it will be possible to develop and maintain a non-violent form of society with no human exploitation".

It was particularly appropriate that Dr. E. U. Condon, of the National Bureau of Standards, Washington, was present on the occasion, as the National Physical Laboratory in its scope will very much take after the Washington Bureau. Dr. Condon pledged hearty co-operation between Indian and American men of science, "and in particular between our sister institutions, the National Physical Laboratory of India and the National Bureau of Standards of U.S.A.".

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

IN January of 1947 the faculty of the Massachusetts Institute of Technology appointed a committee to review the state of education at the Institute*. The committee was instructed to re-examine principles of education that had served as a guide to academic policy at the Institute for almost ninety years and to determine whether they were applicable to the conditions of a new era emerging from the social upheaval and the disasters of war.

The study lasted more than two years and, since the members of the committee believed that major revision should be undertaken only after a basic re-evaluation of the educational philosophy on which the Institute is based, little attention was paid to details of curricula. The committee did, however, examine the concept of professional education upon which the Institute was founded and re-assessed the way of teaching. The task, therefore, was to determine whether the Institute should alter the direction of its effort or apply its methods in new ways or to new areas.

It may be asked why there was felt to be the need of critical appraisal at a time when the Institute was conspicuously healthy and vigorous? In formulating questions to guide the deliberations of the committee, the Faculty expressed concern about the educational implications of changes that have taken place both in the Institute and in the society that it serves; its studies have revealed apprehensiveness among the staff and alumni that, in an exciting inflationary atmosphere when money was easy and physical expansion tempting, members of the Institute may have yielded uncritically to temporary pressures and lost sight of long-range educational goals. The committee also feared that the Institute was adhering to a kind of education that proved successful a generation ago without taking into account significant changes that may have made this kind of education obsolete.

* Report of the Committee on Educational Survey to the Faculty of the Massachusetts Institute of Technology. Pp. vii+148. (Cambridge, Mass.: Technology Press of the Massachusetts Institute of Technology, 1949.)

For these reasons the committee recommended that the Institute should boldly undertake new experiments in education and new explorations into the unknown, withdrawing at the same time from ventures in which its leadership is no longer required. They also made recommendations as to how the Institute might accomplish these purposes most effectively.

Among these were the important points that William Barton Rogers's original concept of higher education with a scientific and technical basis on which the Institute is based, of learning by doing, and of the value of an integrated professional and liberal education, are important guiding principles for its educational policy to-day. These principles, however, must be interpreted broadly and applied with full cognizance of the many changes which have taken place since Rogers founded the Institute in 1865. The committee recognized, too, that the educational programme at the Institute has at times veered unduly towards the vocational and recommended that such tendencies be avoided in future by the adoption and effective application of certain policies and procedures which are elaborated in its Report. Further, despite the fact that the Institute's long period of emphasis upon engineering education at the expense of science, the humanities and social sciences, and perhaps even architecture, was followed by an awakening to a broader mission in the 1930's, the committee felt that the Institute has not yet begun to exploit to the full its opportunities in these other fields.

As a result of the Second World War the rapid growth of the Institute has given rise to dangers of over-expansion, and the committee recommended that a serious effort be made to stabilize the overall size of the Institute within limits that would avoid purposeless dissipation of abilities and resources.

In addition, many factors, including expansion of knowledge and enlarged support of research and development activities, have led to pre-occupation with graduate education at the sacrifice of attention to the undergraduate programme. The committee re-affirmed its belief in Rogers's concept of undergraduate professional education and advocated the establishment of an appropriate balance by strengthening and re-vitalizing undergraduate education; this should not be done by curtailing the achievements of the graduate school. The four-year undergraduate professional education has special advantages to-day, either as direct preparation for a career or for advanced work in science or technology; no advantage would be gained in a gradual lengthening of the undergraduate curriculum to five or six years.

The committee also believes that a scientific and technical environment affords special opportunities for many individuals who wish to acquire a broad cultural education and a full appreciation of modern trends in society. The fundamental problem of technological institutions is that of developing sufficient strength in the social sciences and humanities, and the Institute is advised to take advantage of new opportunities to give the social sciences and humanities full professional status; there is a strong recommendation for the immediate establishment of a school of humanities and social sciences.

The growth of sponsored research at the Institute has provided invaluable opportunities for realizing the educational advantages of an active research and development programme; it has also led to possibilities of indiscriminate participation in activities of

questionable creative value, of dissipation of staff effort in administration, and of dependence upon unreliable short-range financial support. The committee recommended that greater emphasis be given to periodic and realistic evaluations of all aspects of sponsored research in relation to the educational programme.

It was also appreciated that social trends towards a broader base of higher education and financial trends toward decreased endowment incomes pose problems for the Institute no less than for other private institutions, and that, in future, the primary goal of private institutions should be to provide limited groups with useful kinds of education not readily duplicated elsewhere. It is recommended, therefore, that the Institute limits its educational efforts to fields in which it clearly excels and that it should continue to give special emphasis to the pioneering of new ventures in which its leadership could be of distinct value to the community and the nation. The four fields of engineering, science, architecture and planning, and the humanities and social sciences, would be the most appropriate for education and research at the Institute, and the committee believes that the Institute is now in a position to make outstanding contributions to education and the advancement of knowledge in each of these four fields. A general strengthening of the school structure is recommended.

The report also contains details of recommendations and syllabuses drawn up by a committee on general education, as well as proposals for strengthening the physical and intellectual environment of the staff and the Institute.

SOCIAL SCIENCE RESEARCH IN SARAWAK

A RECENT report by Dr. E. R. Leach on "Social Science Research in Sarawak"* is the outcome of a short preliminary study undertaken to prepare the way for a more comprehensive and penetrating "Social–Economic Survey of Sarawak", which, too, is to be sponsored by the Colonial Social Science Research Council. Although the main objective of this short report is stated to be to determine "the requirements of scientific staff and finance", much more attention has been quite rightly paid to a general reconnaissance of the physical and human resources of the territory, and the problems which appear most tempting to the social anthropologist. A programme of work is outlined as a result, which is of interest both to the administrator 'on the spot', who is necessarily absorbed in day-to-day affairs, and to the anthropologist, whose primary interest is the advancement of his science. It is to be hoped that it will be implemented without delay.

The projects contained in this programme are undoubtedly of much theoretical interest. A fair sample is the Melanau Sago Project, under which it is proposed to study a community engaged on the production of sago by traditional methods; this is to be extended to include the study of the process of social transition from pagan to Moslem organization, and the changes in class structure resulting from modern political and economic conditions in a traditionally class-stratified society. The project is therefore both comprehensive and penetrating; the scientific interest is plainly apparent; and its utility is evident from the fact that it will throw light on the producers' end of the Chinese trade and marketing organization, and on the influence of Christian missions on the relations between pagans and Moslems in Melanau society.

The pity of it is that all this work was not done thirty years ago, when the political and social climate was much more favourable and the time-factor was not of the overwhelming importance that it has assumed to-day. Leisurely study of the 'native' is surely something that will prove to be much more typical of the first half of the twentieth century than the second. Our contemporary world is overshadowed by the political consequences of the rise of nationalism in all the under-developed territories, and the social consequences of the rapid growth of population in them. These problems appear as living issues at many points in the report; it must be regretted that the author did not consider himself to be more directly concerned with them. None of the research projects has a sufficiently close bearing on them to justify the expectation that they can be relied on to any great extent to assist in their solution at any time in the near future. Such "purely political" matters as sedition "hardly concern" the author; changes in the attitudes and ways of life of European residents in Sarawak are considered to be "plainly quite outside the scope" of the report. This conclusion ignores the fact that it is the relationship between the peoples of Sarawak and the outside world which is the most critical factor in their social lives to-day; the rigid limits which the author has placed on his responsibilities and his interests can only be regarded as a cause for concern. The time is now long past when it first became evident that the disruptive forces latent in all Colonial societies must be brought under control, and that ways and means of understanding them must be discovered before this can be done. The pace of political and social change is steadily quickening, and a new note of urgency is required in reports of this kind.

* Colonial Office. Colonial Research Studies, No. 1: Social Science Research in Sarawak; a Report on the Possibilities of a Social Economic Survey of Sarawak presented to the Colonial Social Science Research Council. By Dr. E. R. Leach. Pp. ii+93. (London: H.M. Stationery Office, 1950.) 8s. 6d. net.

EDUCATION AND TRAINING OF ELECTRICAL TECHNICIANS

AT the ordinary meeting of the Institution of Electrical Engineers, held on November 2, 1950, Sir Arthur Fleming presented a report entitled "The Education and Training of Electrical Technicians"*. This report is the work of a joint committee set up by the British Electrical and Allied Manufacturers' Association, the Council of the Institution of Electrical Engineers, and the Radio Industry Council.

It will be recalled that the Institution of Electrical Engineers has already published reports dealing with the education and training of professional electrical engineers. In these earlier reports mention was made of the special needs of the members of an important section of the technical personnel of the electrical industry who, for purposes of classification, had been termed technicians. The present report attempts to specify the nature and scope of the activities of the technician and puts forward recommendations for his theoretical and practical training.

* The Education and Training of Electrical Technicians. Pp 32. (London: Institution of Electrical Engineers, 1950.) 1s.

The report defines an electrical technician in the following terms. "An electrical technician is a person who carries out in a responsible manner approved techniques which are *either* common knowledge amongst those who are technically expert in his branch of industry *or* specially prescribed by professional electrical engineers. These techniques are not those of the craftsman, though they may involve manual skill; in many cases they include the skilled use of delicate and complicated instruments and may also require the intelligent and accurate use of approved methods of calculation. They involve practical experience of some limited branch of electrical engineering combined with the ability to complete the details of a project using well-established practice. . . . To become an electrical technician a person must have received a technical education up to a standard at least, and preferably beyond, that of the Ordinary National Certificate in electrical engineering, and in addition must have had training and experience in the particular sphere of electrical engineering in which he is to work."

It is scarcely necessary to emphasize that such a definition embraces a technically important and numerically large section of the electrical industry. At an early stage in the report it is stated that the inquiries upon which it is based "have revealed two main facts. First, that the status of electrical technicians is not nearly so well defined, nor the importance of their systematic training so fully appreciated, as is the case with professional electrical engineers on the one hand or with craftsmen on the other. Professional engineers have been trained for several generations by a system originating in pupilage, while craft training has its roots in medieval apprenticeship, but there is no well-established tradition of training for intermediate occupations."

After listing a typical range of occupations commonly followed by the electrical technician and giving a number of illustrative examples, the report proceeds to a consideration of the qualifications which he needs and to the educational provisions required to meet them. It is considered that, for most technicians, an Ordinary National Certificate course will provide a suitable theoretical foundation; but some reduction in the standard of mathematics normally required may be desirable. Beyond the stage of the National Certificate, courses for technicians will be of a much more specialized character than Higher National Certificate courses. "The courses should be so designed that they can be followed without the assistance of collateral studies, and examinations should be available to which appropriate awards will be given by an examining body such as the City and Guilds of London Institute. The courses should rely as little as possible upon mathematical knowledge, but they should include a large proportion of graphical and of practical work."

The report then deals with practical training. "A most important condition of training is that a trainee should follow a carefully planned and supervised course including, especially in the early stages, formal instruction. In the subsequent stages, training will of necessity largely take the form of experience to be gained by working in different departments or branches of an organization. To help to ensure progressive training, and to attract the right type of recruit, technician apprenticeships extending over a period of four or five years should be offered." Part-time day release, conditional upon satisfactory progress, should be allowed throughout the entire period of apprenticeship. It is recommended that all technician apprenticeship schemes, whether in manufacturing or in operating organizations, should provide for an initial period of about eighteen months duration of training in suitable crafts.

The recommendations of the report are in general terms, and no attempt is made to develop detailed schemes for particular branches of the industry. The views put forward in the report were, in the main, endorsed in the discussion which followed its presentation, it being generally agreed that the institution of suitable schemes of training for technicians is a matter of first importance in the technical development of the electrical industry.

CHEMICAL RESEARCH LABORATORY

REPORT FOR 1949

THE report of the Chemistry Research Board for the year 1949* which, over the signature of its chairman, Sir Norman Haworth, accompanies the report of the Director of the Chemical Research Laboratory, refers to the careful review of the research programme of the High Polymers and Plastics Section of the Laboratory made by the High Polymers Committee. The recommendations of this Committee that the study of the ion-exchange and allied properties of high polymers should continue to be the chief work of the Section, and that research should be begun on the relationships between the properties and chain-length of carefully fractionated linear polymers, with the immediate object of finding improved methods of determining molecular weight distribution, have been endorsed by the Board. In consequence, the work on adhesion has been terminated, as the whole of the available staff is required to make an effective contribution to these first two topics. During the year under review, the Section examined in detail the reaction of polyvinyl chloride with methylamine and ethylenediamine with the view of elucidating the mechanism of the reaction. Exploratory experiments on derivatives of sulphonated cross-linked polystyrene have also been made, and the Director's report includes a brief account of both investigations as well as of those on the preparation and sulphonation of cross-linked polystyrene and the ion-exchange properties of the product. In collaboration with the Low Temperature Research Station, Cambridge, it has been shown that the more basic amino-acids—leucine, histidine, lysine and arginine—can be separated by development displacement from a column of sulphonated polystyrene resin of low degree of cross-linking. In further work on glues for light alloys, the effect of pre-treatment of metals with different adhesives was compared.

An outstanding feature of the Corrosion Group's activities is the increasing amount of time devoted to extra-mural contacts and the handling of technical inquiries, and the Board's report directs special attention to the development of an inhibitor of corrosion consisting of sodium benzoate with a small proportion of sodium nitrite. This has been used effectively in glycol anti-freeze mixtures in the

* Department of Scientific and Industrial Research. Report of the Chemistry Research Board with the Report of the Director of the Chemical Research Laboratory for the Year 1949. Pp. vi+96. (London: H.M. Stationery Office, 1950.) 3s. net.

cooling systems of motor-vehicles with cast iron cylinder heads and blocks with the usual assembly of other metals. The mixed inhibitor can also be incorporated in rubber latex, which can then be used to form a protective film on machined parts. A study of boiler-tube corrosion was initiated during the year on behalf of the British Shipbuilding Research Association. Besides work on corrosion-testing technique, the Corrosion Group has continued its study of the low-temperature oxidation of mild steel, and an electron diffraction camera has been installed which should considerably assist the study of surface films on metals. Sets of the apparatus developed in the Laboratory for the speedier testing of protective coatings on surfaces against the effect of atmospheric corrosion have been made by the British Iron and Steel Research Association and distributed to other laboratories for trial.

The functions of the Microbiology Section have been extended to include the maintenance of cultures of industrially important bacteria, with ultimate responsibility for the maintenance of a National Collection of such bacteria. Bacteria previously held at the National Collection of Type Cultures have been taken over; but it was anticipated that it would take until the end of 1950 to examine and catalogue them. The fundamental investigations on the biochemistry of sulphate-reducing bacteria have been intensified, and the competitive inhibition of this reduction by selenate is being applied experimentally by incorporating selenate in protective coatings for ferrous pipes buried in sulphate-bearing clay soils. Biological methods for the control of the nuisance of evil-smelling pools produced by the activities of these bacteria are also being investigated.

Work for the Division of Atomic Energy, Ministry of Supply, on the analysis and concentration of uranium in minerals and ores has continued on an increasing scale, including the development and application of methods, based on solvent extraction in conjunction with the use of cellulose and other solid adsorbents, for preparing and analysing inorganic substances, including uranium products. Other work of the Radiochemical Group on the precipitation of uranium and other metals from solution under controlled conditions has also proved valuable in the development of enrichment processes for uranium from low-grade ores. Besides chemical methods of analysis, this Group has made numerous studies in radioactive methods of analysis, and reports substantial progress in polarographic methods for the direct determination of uranium in solutions containing other metals.

The Inorganic Group, which is now equipped with a Jarrell-Ash grating spectrograph, has successfully completed a semi-scale trial of its method for extracting germanium and gallium from flue dust by fusion with caustic soda and obtained an 80 per cent overall yield. A new investigation on the conversion of phosphate rock into forms of fertilizer which are easily assimilated by plants and in which less sulphuric acid is required has yielded promising results in preliminary work with mixtures of nitric and sulphuric acid. In chromatography, a method has been developed for the quantitative separation of nickel, manganese, cobalt, copper and iron in solution as chlorides on paper strips, and the method for nickel, cobalt, copper and iron has been extended to separations on cellulose columns. Much of the work of the Spectroscopic Laboratory has been concerned with the quantitative examination of products derived from eluates obtained in this work with cellulose columns.

A prominent part of the work of the Organic Group is now the determination of accurate physical and physico-chemical data for pure organic compounds, and besides informal discussions between the Director of the Chemical Research Laboratory and Prof. D. M. Newitt, the Superintendent of the Physics Division of the National Physical Laboratory, to co-ordinate work in this field, there has been co-operation with the Hydrocarbon Research Group of the Institute of Petroleum. In consequence, the Laboratory has undertaken responsibility for procuring and distributing a range of standard pure hydrocarbons required for calibrating mass-spectrometers and other purposes. The Purification and Measurements Section has developed methods for the purification of β- and γ-picoline and 2 : 6-lutidine and also new thermodynamic tests for vapour–liquid equilibrium data in ternary systems. An apparatus has been designed for the automatic recording of freezing-point curves, and a method worked out for the determination of 4-methyl-2 : 6-di-tertiary-butylphenol in industrial mixture by infra-red absorption spectroscopy, as well as for the determination of small quantities of water in pyridine homologues. In the Organic Intermediates Section, progress is reported in identifying and synthesizing insecticidal compounds contained in the piperidine- and other nitrogen-containing fractions. Two homologous series of N-substituted piperidines are being synthesized for evaluation, and further work has been done on the hydrogenation of diphenylene oxide and *o*-diphenol, as well as on the polymers and co-polymers of acenaphthylene. A considerable amount of effort has been given to the synthesis of carbon-13 labelled intermediates from enriched potassium cyanide, and progress is reported in the elaboration of adequate methods for intermediates. A number of polyfunctional halides and bases have been prepared for the synthesis of ion-exchange resins, and to obtain a non-polar lubrication standard the hydrocarbon, docosane, was synthesized from lauric acid.

GOVERNMENT EXPENDITURE IN THE WELFARE STATE

RECENT reports from the Committee on Public Accounts have indicated that the mounting scale of expenditure on the universities and similar institutions and on the Department of Scientific and Industrial Research is leading to requests for closer public accountability of such expenditure, even by those who are most concerned to safeguard the independence of the universities and who are alive to the danger of cramping research activities by petty restrictions. Possibly the spirit of such requests may be satisfied by a greater disposition on the part of these organizations to recognize that full publication of results as early as possible is a return which the nation is entitled to expect, as indeed was pointed out by one speaker at the British Association meeting in Birmingham; but it is clear from two recent broadsheets issued by Political and Economic Planning that there is a real danger, and that some new means of accountability may have to be devised to satisfy the nation that there is no excessive waste and that a reasonable return is being secured.

The first of these broadsheets, No. 317, dealing with government spending, makes it clear that pressure to this end is likely to arise out of the acute problem of adapting the British economy to a big increase in defence expenditure. The broadsheet, it is true, is concerned chiefly with examining the nature of government spending and its effects with the view of determining whether it is true that no reduction in government expenditure can be made without doing more harm than good, or whether, on the contrary, a high rate of government spending is a drag on economic progress and a hindrance to the long-term solution of the foreign trade problem.

The survey indicates some of the consequences of the Government's need for balancing the claims of defence against those of other economic activities and to decide such questions as the rate of house-building or the amount to be spent on hospitals. The Government, it is pointed out, has only a limited control over some parts of the economy. It must accept that increased spending by public authorities will probably be at the expense of the provision of industrial equipment rather than of consumption. The welfare State involves a high level of taxation to cover large spending by public authorities and large monetary transfers. This tends to diminish the traditional incentive to effort and, in the absence of new ones, to check production. This danger may impose limits on what the Government can do with safety.

The most important conclusion reached here by Political and Economic Planning is that, while the dependence of decisions on policy to some extent on personal judgment is admitted, with consequent room for dispute, the area of dispute could be reduced if more facts and figures were available. Planning decisions must be based on a knowledge of the relevant facts, so far as they can be ascertained. It is true that the total effects of a tax, or of taxation as a whole, cannot be assessed with any degree of accuracy; but at present the planning authorities lack knowledge of ascertainable facts. The figures on government spending are not available in the most illuminating form.

A new classification of government spending may be desirable, and P E P argues convincingly that a more illuminating presentation of the facts about government spending would confer economic benefits by leading to a better organization of the economy. Since the official statisticians of the Treasury and the Cabinet Office do not appear to have supplied the Government with all the ascertainable facts about the activity which is most directly under its control, the broadsheet suggests that the official statisticians should share the work with such bodies as the Oxford University Institute of Statistics and the Department of Applied Economics at Cambridge. The lead must come from the Civil Service, since the first step is the remodelling of the system of accounting and recording in the various departments. If the raw material were thus improved, there is little doubt that the Treasury and the Cabinet Office would receive plenty of outside help in the new research which would be made possible.

The second of these broadsheets, No. 318, dealing with government and industry, goes further into the doctrine of public accountability, but mainly from the point of view of the relationship of the Government to industry in the so-called 'mixed economy' which Britain has now come to be. It attempts to trace the shape of that relationship as it was developing from the full control of the War and its immediate aftermath to a more liberal system. The broadsheet assumes that the place of the Government in that relationship will continue to be larger than in days gone by, whatever political party holds the power. Some of the fundamental questions which have to be faced in the relations of Government to industry are well summarized in the second broadsheet. The first is the fundamental political dilemma of peace-time: Is Government intervention in industry on the present scale necessary? Further, if there is a need, is the present mixed system—'voluntarism', with a background of control—the right one in principle? Does the system as it operates to-day create the best possible psychological atmosphere? What is its effect on costs, to the firm and to the community? Lastly, in the system as it has developed, is the consumer adequately protected?

SCIENTIFIC COUNCIL FOR AFRICA

EARLY in 1951 the Scientific Council for Africa South of the Sahara held its first session in Nairobi under the chairmanship of Dr. P. J. du Toit of South Africa, and was attended by Prof. J. Millot (Madagascar), Dr. F. J. Cambournac (Portugal), Sir Alexander Carr-Saunders (United Kingdom), Dr. B. A. Keen (British East Africa), Dr. A. Mendes Correa (Portugal), Prof. T. Monod (French West Africa), Col. H. W. Mulligan (Nigeria), Dr. B. F. J. Schonland (South Africa), Mr. N. P. Sellick (Southern Rhodesia), Dr. Georges J. Bone (Belgian Congo) and Prof. Trochain (French Equatorial Africa)*.

Being the inaugural meeting, the Council was chiefly concerned with problems of organization and method. It proved possible, however, to devote considerable attention to examination of the fifty-three resolutions on scientific collaboration in Africa adopted at the African Regional Scientific Conference in Johannesburg in 1950. These resolutions were thoroughly sifted, and priorities were allocated to assist the Council and governmental and other authorities concerned in carrying out these recommendations. Among the proposals which the Council decided should be examined in detail as a first priority were the following: the establishment of an Inter-African Regional Bureau on Geology; the achievement of cartographic uniformity in the maps of Africa, and the preparation of special regional maps dealing with such subjects as geology, climatology, vegetation, vector-borne diseases, etc.; the extension of co-ordinated development in the field of hydrology and water conservation; the calling of a specialist meeting on housing and building research; and the co-ordination of scientific library and bibliography services.

It was reported that considerable progress had already been made in carrying out a number of the Johannesburg Conference proposals. Arrangements were made for the appointment of honorary regional consultants and correspondents in Africa representing all the main scientific disciplines.

To avoid duplication and overlapping of functions with those undertaken by other organizations, careful attention was given to the recommendations of the several African scientific conferences which have been held in the past few years on such specialized subjects as trypanosomiasis, rinderpest and soil conservation.

* *South African J. Sci.*, **6**, January 1951.

Arrangements were made for submission to the authorities concerned of suggestions about items to be discussed at the African scientific and technical conferences already planned for the next two or three years; the Council endorsed the view that international technical conferences should not continue to be convened on the scale of the past three or four years. Major technical conferences in a particular field were regarded as fulfilling most valuable functions if held at intervals of five or more years; but during such intervals the necessary consultation and continuity could best be achieved by arranging meetings of small groups of specialists.

In order effectively to initiate the work of the Council, it was decided that the Council's secretariat should be as mobile as possible during the first year of its operation and that, during this period, it should visit the major centres in Africa, spending one or two months at each centre. The secretariat is expected to begin full-time work as from about the middle of this year and will be under the direction of Dr. E. B. Worthington, at present scientific secretary of the East African High Commission.

SEISMOLOGY IN GREAT BRITAIN, 1949-50

THE fifty-fifth annual report of the Seismological Investigations Committee of the British Association for the Advancement of Science has recently been published[1]. Continuing the work of Davison, Dr. A. T. J. Dollar has collected together macroseismic and other information into a paper entitled "Catalogue of Scottish Earthquakes, 1916–49"[2]. During this period there was evidence of 120 tectonic earthquakes, including nine principal earthquakes with associated accessory shocks, and five others of secondary or sympathetic origin, but no unequivocal evidence for twin earthquakes. The positions of epicentres indicate nine seismic regions, mainly grouped around the margins of the Grampian Highlands. Of these regions, Glen More, Breadalbane, Ochil Hills and south Argyllshire showed seismic activities noticeably greater than those in the four regions of Clydesdale, Pentland Hills, Lowther Hills and the Shetland Islands. Among seismic centres, Comrie remained outstanding with fifteen earthquakes for the period, followed by Stirling with eleven earthquakes, and Menstrie, Lochgilphead and Lochaber each with six earthquakes. Damage produced by these earthquakes was slight and almost entirely structural, generally involving no more than the dislodgment of tiles, slates or chimney-pots. In one case, the overthrow of a gable-end near Carron Bridge may have been occasioned by earth tremors in Stirling on July 16, 1940. No human injuries appear to have been caused, either directly or indirectly, by any of these disturbances.

The International Seismological Summary continues to be computed by J. S. Hughes and his staff, working at Kew Observatory by courtesy of the director of the Meteorological Office. On November 5, 1938, a very large, shallow-focus earthquake occurred near Hukusima, which was recorded at nearly every seismological observatory in the world and was followed by many after-shocks from nearly the same epicentre. This involved an unprecedented quantity of observational material which it was necessary to work up, and has caused some delay in publication. At the time of writing, calculations on data from April 1940 are in progress and completed calculations for the last quarter of 1939 are in the Press. During 1950 the gap between the dates of the earthquakes and the distribution of the International Seismological Summary concerning them has been noticeably diminished.

It is pleasing to note the increased interest in experimental seismology in British universities and research establishments, in addition to the routine investigations made by oil companies. The results of Admiralty research on microseisms have appeared in two papers. The first, entitled "A Theory of the Origin of Microseisms", is by M. S. Longuet-Higgins[3]. It is suggested that microseisms originate from standing waves on the surface of the ocean. The general conditions for fluctuations in the mean pressure over a wide area of the sea surface is that the frequency spectrum should contain groups of waves of the same wave-length travelling in opposite directions. The pressure fluctuations are then of twice the frequency of the corresponding waves and are proportional to the product of the wave amplitudes. Waves of compression in the ocean- and sea-bed should be set up, which may be of sufficient amplitude to be recorded as microseisms. For certain depths of the ocean the displacements will be increased by a factor of the order of 5 owing to resonance. Suitable conditions of wave interference over deep water would be probably greater than the effect of coastal wave reflexion. The second paper, by J. Darbyshire, is on the "Identification of Microseismic Activity with Sea Waves"[4]. In this paper three series of simultaneous wave and microseism records are examined. They give a clear indication that bands of microseismic waves from different sources can be distinguished by submitting seismograph records to frequency analysis. The agreement between the results of analysis and the theoretical expectation from the prevailing meteorological conditions appears to justify the assumption that microseismic waves of different periods travel independently. Under the simple meteorological conditions that have been studied, each band of microseismic activity can be identified with a band of sea waves of twice its period.

At the Imperial College of Science and Technology, London, the elastic properties of rocks at frequencies between 40 and 120 c./s. have been investigated, and also experiments have been made on the propagation of elastic waves, of frequency 500–1,000 c./s. At the Department of Mining, University of Leeds, field experiments using a Leet three-component seismograph have been made on ground amplitudes and frequencies resulting from blasting operations. At the Department of Geodesy and Geophysics, University of Cambridge, experiments have been made on refraction shooting at sea[5]. Dr. P. L. Willmore has also further developed his seismograph and it is about to be produced by Messrs. Hilger and Watts, Ltd., who also produce the new Milne-Shaw instruments.

As already mentioned[6], Dr. R. Stoneley has discussed the effect of a low-velocity layer below the surface layers of continents, on the amplitudes of surface waves[7].

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LETTERS TO THE EDITORS

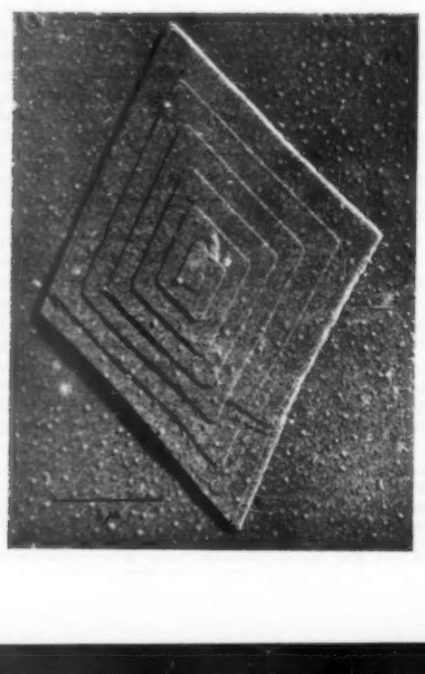
The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Observation of Spiral Growth-Steps in *n*-Paraffin Single Crystals in the Electron Microscope

The effect of dislocations on the growth of crystals was discussed in an article by N. F. Mott[1] published in *Nature* of February 25, 1950. Optical evidence which had been obtained by an interference method by Griffin[2] was cited in favour of spiral growth-steps ending on screw dislocations occurring in beryl crystals, thus supporting the growth mechanism which had been suggested by Frank[3] to account for crystal growth at very low supersaturation values.

Examination in the electron microscope of single crystals of the *n*-paraffin, *n*-hexatriacontane, $C_{36}H_{74}$, has given striking evidence that these crystals do grow out from a dislocation in the primary nucleus.

Small crystals of *n*-hexatriacontane, grown from a solution in petroleum ether, were shadow-cast with palladium[4] and examined in a Philips's electron microscope. The accompanying micrograph shows the simplest type of crystal observed. This, and all the other crystals examined, showed the presence of molecular steps of the type first observed by Robert and Buzon[5] in preparations of commercial paraffin. Closer examination of our micrograph shows, however, that the molecular step edge on the crystal face runs in a continuous spiral from the apex, that is, 'the growth-point', of the crystal to the base, and that the crystals are, in fact, as Frank has suggested, growing, "up a spiral staircase", and not in a series of closed terraces. This, of course, implies that during growth fresh molecules can always condense on a monomolecular edge, and that successive molecular edges do not have to be initiated on the growing crystal face. Under these conditions, growth takes place at a low degree of supersaturation in accordance with the experimental evidence of Volmer and Schultze[6].



The micrograph shown here is an example of the simplest type of spiral dislocation seen in our experiments. Other micrographs show the effects of multiple dislocations on crystal-growth, and these, together with the detailed conclusions which can be drawn from our observations, will be published elsewhere.

We wish to thank Prof. J. M. Robertson for his interest in these results. We are indebted to the Rockefeller Foundation for a grant for equipment, and to Imperial Chemical Industries, Ltd., for research fellowships. The specimen of *n*-hexatriacontane was kindly supplied by Mr. C. W. Bunn.

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Occurrence of Stripped Nuclei of Neon in Primary Cosmic Rays

Bradt and Peters[1], in their analysis of the primary cosmic radiation as observed in the out-of-the-atmosphere observations with the plate technique, have given the completely stripped nucleus of neon as one of the main components of the heavier cosmic particles. In fact, the relative abundance is given as almost the same as that of oxygen-16 (*vide* Fig. 13, p. 66, of their paper).

It appears that if the identification of the stripped nucleus of neon as one of the main constituents of primary cosmic particles be correct, and is confirmed by subsequent observations, it constitutes a very strong argument against the hypothesis that the sun is the source of cosmic particles received on the earth[2,3]. For to have stripped nuclei of neon from the sun, it must be first demonstrated that neon exists on the sun and is at least once ionized on the photosphere or the chromosphere. The evidence on these points, as will be shown presently, is absolutely negative, in spite of the fact that strong lines of Ne and Ne^+ occur within the solar range of wavelengths (3,000–10,000 A.).

It is true that the fundamental lines of Ne and Ne^+ occur in the far ultra-violet, and the lines which occur in the solar range belong to the transitions:

$$\left.\begin{array}{l} 1s^2.2s^2\,(2p^5.3s-2p^5.3p) \text{ or higher transitions for Ne} \\ 1s^2.2s^2\,(2p^4.3s-2p^4.3p) \text{ or higher transitions for } Ne^+. \end{array}\right\} \quad (A)$$

But the physical conditions on the sun, as we know, are such that if neon existed there at even moderate strengths the lines of Ne, Ne^+ belonging to the above-mentioned combinations could not escape detection, at least in the flash spectrum of the sun. An analogous case is afforded by He and He^+, which have their fundamental lines in the extreme ultra-violet; but of the higher transition lines, only λ 10,830·38, $1s.2p^3S_1-1s.2p^3P_1$ is found as an absorption line in the Fraunhofer infra-red spectrum[4]; and none of the other lines of He, $1s.(2s^{1,3}S-np^{1,3}P)$, $1s.(2p^{1,3}P-nd)$, is found ordinarily in the Fraunhofer spectrum, except when the solar atmosphere is disturbed. But the lines $1s.2p^{1,3}P-1s.nd^{1,3}D$, which include the well-known D_3 and other higher transition lines of helium, are found in great strength in the solar chromosphere; thus proving that though helium exists in great

strength in the higher solar atmosphere, it is difficult of observation in the Fraunhofer spectrum owing to the large excitation potential of its excited levels, which can give rise to Fraunhofer lines by absorption. But determinations of the abundance of helium to hydrogen in the chromosphere can be obtained on certain plausible assumptions, and are variously given as 1 : 14, 1 : 33, etc.

The presence of ionized helium in the flash spectrum is indicated through the line λ 4,685·91, $\nu = 4N\left(\frac{1}{3^2} - \frac{1}{4^2}\right)$. This is unexpected, on account of the high ionization potential of helium (24·465 volts), and the extra excitation required to raise normal He^+ to the 4-quantum levels. The physical mechanism producing He^+ in the chromosphere is still unknown, and the reader may be referred to a suggestion which I myself have made[5].

If neon were present at some strength in the sun, we could expect, from analogy with helium, that lines of both Ne and Ne^+ would be present in the flash spectrum of the sun. But, in spite of laborious attempts, not a single coincidence of the numerous lines of Ne and Ne^+ belonging to combinations (*A*) could be found in the table of the flash-spectrum of the sun published by Menzel[6] (1931) or Mitchell[7] (1947). We must, therefore, conclude that both Ne and Ne^+ are definitely absent from the atmosphere of the sun.

So far as I know, no lines of neon or of any inert gas except helium have been found in the spectra of stars belonging to the main sequence. Forbidden lines of Ne^{2+}, Ne^{3+}, Ne^{4+} are found in the spectra of the nebulosity which is formed from gases ejected by a nova, and lines (*A*) of Ne and Ne^+ have been found in certain *B*- and *A*-stars, which show abnormal characteristics like τ-Scorpii. These form less than 10^{-4} times the number of stars the spectra of which have been examined, and we are therefore driven to the conclusion that occurrence of Ne and Ne^+ in these rare bodies is due to some extraordinary cosmogenic process. The attempt of Harrison[8] to prove the existence of neon in the interior of the sun from opacity data is inconclusive, as his arguments can equally well apply to neighbouring elements like fluorine or sodium.

There is therefore at present no positive evidence of the presence of Ne or Ne^+ in the sun or the usual run of stars, and this is a strong point against the hypothesis of the solar origin of our local primary cosmic ray particles. The theories which ascribe a high cosmic abundance to neon are not borne out by stellar data.

I wish to express my indebtedness to Dr. B. Peters for discussion of these points during the conference on elementary particles held at Bombay in December 1950, under the auspices of the Tata Institute of Fundamental Research.

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Ultrasonic Absorption in Normal- and Para-Hydrogen

Several years ago it was found by one of us, together with P. Mariens[1] and L. Thys[2], that the experimental values found for the ultrasonic absorption coefficient is much larger than the theoretical value computed by means of the equation of Kirchhoff–Stokes (viscosity and heat conductivity). This deviation was explained as due to the lag in the establishment of equilibrium between the rotational and the translational energy. Since these measurements were made, new and more accurate measurements have been carried out by one of us together with R. Vermaelen[3], and also on heavy hydrogen. All those determinations were made by means of an acoustical interferometer, in which different quartz crystals and different resonator tubes were used. Later, the existence of this relaxation for the rotational energy was proved by dispersion measurements, respectively by E. S. Stewart, J. L. Stewart and J. C. Hubbard[4]. On the other hand, the absorption coefficients found by the use of the acoustical interferometer have been criticized by P. E. Krasnooshkin[5] and more recently by J. F. W. Bell[6]. Their argument is that an excess of absorption should be caused by the non-uniform vibration of the crystal surface, which produces excitation of the transverse modes of resonance in the interferometer tube. This excess of absorption can be determined by plotting the observed absorption coefficient α_{obs} as a function of the pressure p, whereby

$$\alpha_{obs} = \frac{\alpha_0 \cdot p_0}{p} + \alpha_1$$

(α_0 is absorption coefficient corresponding to atmospheric pressure p_0, and α_1 is the parasite absorption coefficient). In order to check this theory, we have carried out a series of very accurate measurements

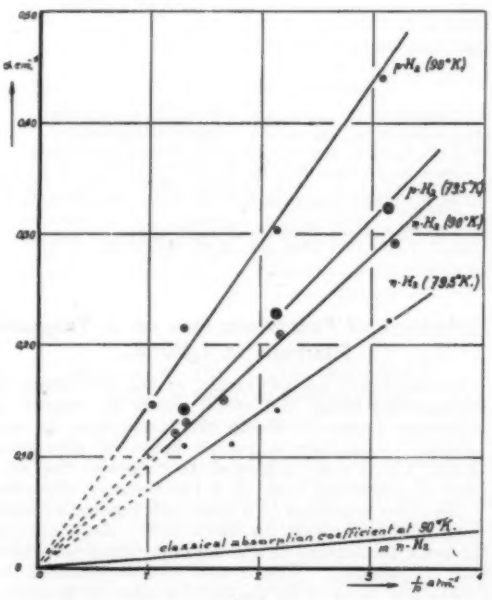

Fig. 1

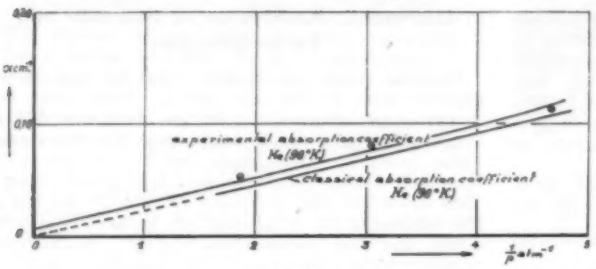

Fig. 2

(frequency = 500·0 kc./s.) as a function of pressure and temperature (liquid oxygen temperatures) in normal- and para-hydrogen and helium gas.

A comparison between the absorption coefficient for the two modifications of hydrogen at liquid-oxygen temperatures, where the velocity is approximately the same, can be considered as a direct control of the influence of the rotational energy on the absorption coefficient.

A plot of our measurements for the case of normal- and para-hydrogen is given in Fig. 1, whereby α_{obs} is plotted against $1/p$. From this graph, α_1 is practically zero. The classical absorption coefficient has also been plotted on the graph.

In Fig. 2 are shown the experimental results (full line) for helium gas at the boiling point of liquid oxygen. The theoretical absorption coefficient (broken line), computed from the experimental data for the heat conductivity, the viscosity coefficient and the specific heat published in "Helium" by W. H. Keesom (Elsevier, Amsterdam, 1942) is also shown. The agreement of the two curves is quite good, notwithstanding that the measurements are very difficult because of the small value of the absorption coefficient of helium.

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Life-time of Potassium Ions on a Tungsten Filament at 1,460° K.

Experiments are proceeding at the University of Birmingham using high-speed rotors as sources of molecular beams[1]. Using this technique, it was possible to produce a pulsed beam of potassium atoms, which was employed to measure the life-time of potassium ions on a hot tungsten filament.

The rotor consisted of a steel rod, tapered at both ends, spinning about its short axis. Each arm of the rotor terminated in a small cup, which was filled with potassium. The rotor was accelerated to 1,500 c.p.s. *in vacuo* by means of a rotating magnetic field. The heating of the rotor by eddy-current losses resulted in the evaporation of the potassium. Pulses of potassium atoms were received by a tungsten filament placed in a tube situated at a tangent to the path swept by the rotor tips.

Potassium evaporates from a hot tungsten surface as positive potassium ions. This results from the fact that the electron work function of a tungsten surface is greater than the ionization potential of potassium. Thus pulses of potassium atoms incident on the hot tungsten filament resulted in pulses of potassium ions being received at a cathode partially surrounding the filament. These pulses were recorded by means of an amplifier and a cathode ray oscillograph.

The principal time constants which affected the observed pulses were thermal and electrical. The thermal time constant resulted from the fact that the potassium ions did not leave the filament instantaneously, but with a speed proportional to the concentration of potassium ions on the filament. The electrical time constant resulted from the resistance and capacity at the amplifier input.

Pulses were obtained with a thermal time constant corresponding to a filament temperature T and a negligible electrical time constant. Pulses of identical size and shape were obtained with a negligible thermal time constant (filament temperature 1,900° K.) by increasing the electrical time constant to a value CR by means of a variable capacity. Under these conditions, it is easy to show that the thermal time constant at temperature T is equal to CR. By this method the time constant for the emission of positive ions from a tungsten surface at a temperature of 1,460° K. was found to be 3×10^{-5} sec.

The temperature of the filament was deduced from its mass, length and heating current, using Jones and Langmuir's tables[2]. The potential across the filament was also measured, and provided an independent determination of the temperature.

The evaporation of potassium ions from a hot tungsten surface has been studied by Moon and Oliphant[3] and by Evans[4]. These investigations were conducted at surface temperatures of about 1,000° K. and showed that the decay of a deposit of potassium upon a hot tungsten surface was exponential. Their results demonstrated that the reciprocal of the time constant was proportional to $\exp(-\varphi/KT)$, where K is Boltzmann's constant, T is the absolute temperature, and φ is the work function of the surface for potassium ions.

The measurement described in this communication agrees with an extrapolation of Evans's results, from which he deduced a value of φ equal to $2{\cdot}4_3$ eV. The concentrations of potassium upon the tungsten surfaces were well below monomolecular in both Evans's and our own experiments.

We are grateful to Prof. P. B. Moon for suggesting this application of our technique.

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Examination of Metals by Polarized Light

RECENTLY, several papers have been published on the use of polarized light for revealing the grain structure of metals and alloys. Hone and Pearson[1] showed that by examining under polarized light a polished aluminium surface which had been anodized in a suitable electrolyte, the grain structure was revealed, differently oriented grains appearing with different brightnesses. Woodward[2], by etching 'Monel' metal in a specific reagent, has found similar effects. Polished surfaces of aluminium and 'Monel' metal, being optically isotropic, do not react to polarized light as do the optically anisotropic surfaces of tin, zinc, cadmium, etc., and the above authors[1,2] have attributed the optical anisotropy of the anodized aluminium and etched 'Monel' metal to the anisotropic properties of the surface film formed during anodizing or etching. Although this explanation may be correct, there is a possible alternative which involves the surface contour of the specimen, for it is well known that if pearlite is examined under polarized light no reaction occurs unless the specimen is etched. This has been shown convincingly by Baeyertz[3] to be due to the presence of fine parallel grooves on the surface, formed by etching away the ferrite and leaving the cementite lamellæ in relief. Furthermore, Jones[4] has shown that polarization effects can be produced by deeply etching a metal surface.

To decide which of these two explanations is correct, electrolytically polished zinc and cadmium, aluminium electrolytically polished and anodized in a solution containing 49 per cent water, 49 per cent ethyl alcohol and 2 per cent hydrofluoric acid at 30 volts, and 'Monel' metal etched according to Woodward[2], were examined before and after evaporating a silver film, approximately 800 A. thick, on to the prepared surfaces. If the polarization effects are due to optical anisotropy, the silver, being optically isotropic, should destroy them; whereas, if they are due to the surface contour, they should still remain after silvering, for it is known that evaporated silver takes up the surface contour of the surface on which it is deposited (that is, any grooves present before silvering will also be present after).

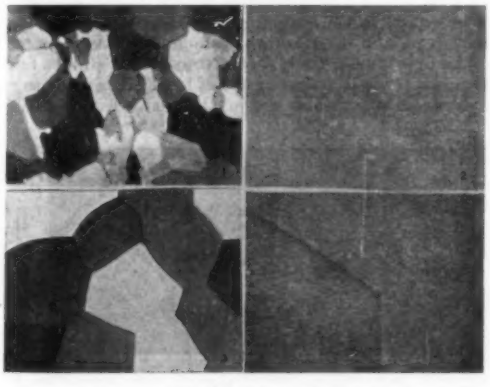

Fig. 1. Electrolytically polished cadmium: crossed nicols. × 125
Fig. 2. Same as Fig. 1 with silver film present: crossed nicols. × 125
Fig. 3. Polished and anodized aluminium with silver film present: crossed nicols. × 20
Fig. 4. Same as Fig. 3 photographed under phase-contrast illumination. × 750

Without the silver film, all four surfaces reacted to polarized light, a typical example being shown in Fig. 1. After silvering, the zinc and cadmium showed no polarization effects (see Fig. 2), whereas both the etched 'Monel' metal and anodized aluminium still reacted to polarized light after deposition of the silver film (see Fig. 3). Similar results were also obtained on aluminium which was electrolytically polished and anodized in the way described by Hone and Pearson[1]. It is clear, therefore, that the polarization effects obtained with anodized aluminium and etched 'Monel' metal are due to some surface structure and not to true optical anisotropy. The silvered aluminium and 'Monel' metal surfaces were examined under the phase-contrast microscope, which is very sensitive in revealing small differences of level, to discover if some such structure could be seen. A structure was clearly seen on the aluminium (see Fig. 4), and faint evidence of one on the 'Monel' metal. Electron microscopic examination of the 'Monel' confirmed that a very fine structure was present. That the structure shown in Fig. 4 is due to the anodized aluminium surface and not to the silver alone is shown by the fact that a silver film evaporated on to an electrolytically polished aluminium surface showed no markings when examined under the phase-contrast microscope.

Further support for these conclusions was found in the observation that if polished aluminium is anodized in a solution containing 12 per cent disodium acid phosphate and 0·4 per cent sulphuric acid in water, which according to Edwards and Keller[5] gives a structureless oxide coating as seen by the electron microscope, no polarization effects are observed.

We thank the Director and Council of the British Non-Ferrous Metals Research Association for permission to publish this communication.

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Source of the Light recorded in Photographs of Detonating Explosives

IT is now generally recognized that a large part of the light arising from the detonation of a condensed explosive cartridge is due to the system of shock waves produced in the surrounding air[1]. When the air is replaced, for example, by water, the total luminosity is greatly reduced. The wave-speed photographs shown in Fig. 1 illustrate this effect.

Fig. 1. Side-on rotating-mirror photograph of blasting gelatine detonating at high velocity in (*a*) air; (*b*) water

The light still reaching the camera when atmospheric shocks are eliminated might be supposed to arise from chemical reaction; and indeed a measurement of the reaction time has been proposed[3] in terms of the breadth of traces such as that shown in Fig. 1(*b*). Even if the light were due to reaction, however, we should have no guarantee that its duration corresponded to the reaction time—it might well be either longer or shorter; and, in fact, it appears unsafe to assume that the light from a granular explosive is necessarily associated with reaction at all. A theory of reaction-zone structure in granular explosives, which it is hoped to publish shortly, leads one to expect very high temperatures in the air-pockets between the explosive grains, before reaction commences. It is at least possible that the light comes partly (or even entirely) from these.

In order to test this suggestion, composite charges were made by loading common salt and a plastic explosive in alternate layers in a celluloid tube. The charges were enclosed in wide water-filled glass tubes and fired in a side-on position in front of a high-speed drum camera. Fig. 2 shows a typical record. Contrary to what might at first glance be supposed, the intense streaks of light correspond to the layers of salt and not to those of explosive; this is made clear by reference to the key. The layers of explosive give very faint wave-traces on the original negative; these are not detectable on the print. There is no light from the water shock.

That the light emitted by the salt layers arose within the depth of the salt and not merely on its surface was confirmed by firing two further shots, similar to the above, in one of which the salt was blackened by mixing it with 1 per cent of lamp-black. The blackened salt was found to contribute much less light than the translucent material.

A final demonstration was provided by firing three cartridges in a head-on position towards the camera. (In order to avoid damaging the lens, the cartridges were actually fired downward, and a 45°-mirror used for reflecting the light; but this does not affect the argument.) The end of each cartridge remote from the detonator and nearest to the lens was butted tightly against a small block of 'Perspex'. Since only this end surface is viewed by the camera, water confinement is then unnecessary, and the sloping lines in Fig. 3*a*, *b*, *c* represent lateral air shocks: they are cut short by the limited size of the mirror. Between these lateral traces is a dark space, where the undetonated layers of explosive obscure the approaching wave. This can become visible only when it reaches (or nears) the end of the charge. Fig. 3*a*, which corresponds to a cartridge of the plastic explosive alone, shows practically no light from the detonation wave: a diffuse flash some 30 microsec. later was due to impact on the mirror. However, when a half-inch thick layer of common salt is interposed between explosive and 'Perspex' (Fig. 3*c*), a most intense band of light is recorded. Fig. 3*b* provides interesting confirmation: in this case the explosive was butted directly against the 'Perspex'; but a series of parallel scores were first made on its end surface. These produce bright flashes of light when the wave reaches them. For comparison, Fig. 3*d* is a record of a cartridge of the *granular* explosive *PETN*. This produces a band of light comparable with that arising from the salt in Fig. 3*c*.

The significance of these photographs is clear. No appreciable light is emitted by the detonation reaction in the plastic explosive, the texture of which almost precludes the presence of air pockets; but copious light is emitted by the non-reactive salt, which, of course, contains abundant air pockets. When air-spaces are artificially introduced into the plastic explosive, it becomes luminous on detonation. Finally, a granular explosive, less ***brisant*** than the other, emits intense light.

It would be premature, on the basis of these experiments alone, to suggest that none of the light recorded from detonating condensed explosives is due to chemical reaction. Instances may be quoted, such as liquid nitroglycerine, where a luminous wave is observed in the (apparent) absence of air-bubbles. However, the observations which we have reported make it probable that, after atmospheric shocks have been suppressed, a great part at least of the remaining light from a granular detonating explosive is due to

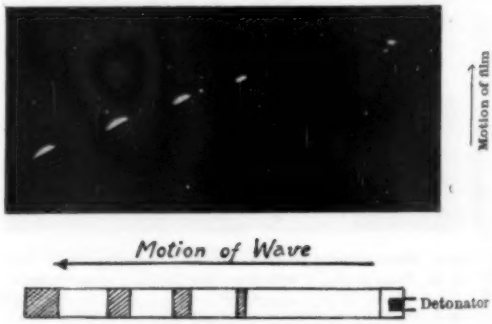

Fig. 2. Side-on photograph of composite charge fired under water; shaded portions, sodium chloride; unshaded, plastic explosive

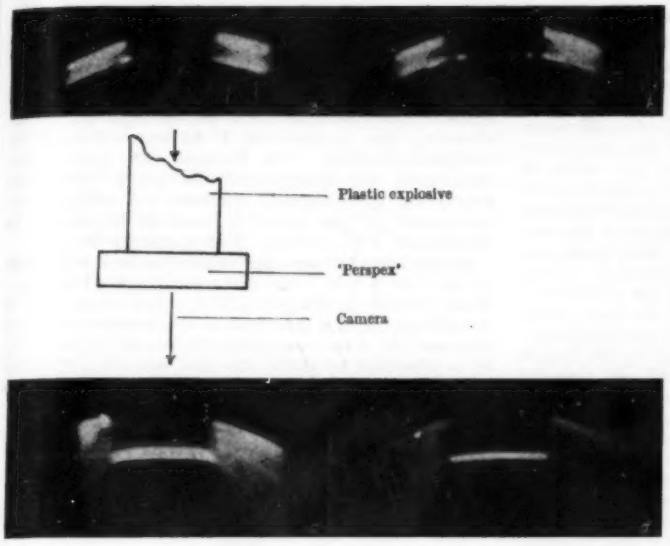

Fig. 3. End-on photographs through 'Perspex' blocks: (*a*) plastic explosive, end plane; (*b*) plastic explosive, end scratched; (*c*) plastic explosive and common salt; (*d*) *PETN*

compression of the air pockets between the explosive grains. This confirms the theory referred to above, and simultaneously casts doubt on any estimate of reaction time in terms of the duration of luminosity.

The high-speed photographs were taken by Mr. J. King, to whom my thanks are due.

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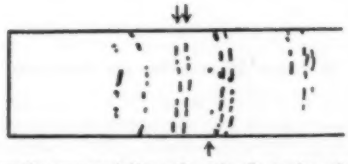
New Approaches to the Interpretation of X-Ray Powder Photographs

THE interpretation of powder photographs, despite recent attempts at systematization[1–3], remains still largely an art, and any aids towards simplification are greatly to be welcomed. We have discovered that some help can be given by photographs that are usually classed as 'poor', in the sense that the grain size of the specimen is large and the lines are therefore rather 'spotty'.

A general advantage of such photographs is that they give some idea of the multiplicity factors[4] of the reflexions; if the number of spots contributing to a particular line is abnormally small, one can be reasonably sure that the multiplicity factor is small, and therefore that the indices are fairly simple—for example, *h*00. This is illustrated by the accompanying diagram, which is a diagrammatic representation of the first few lines of a powder photograph of the alloy CdMg; the line marked with the lower arrow is more sparsely populated than its neighbours and therefore is likely to be of the type *h*00.

A point of more limited application also arises from the photograph: the two lines marked by the upper arrows have the same general appearance, and we may therefore deduce that they have a common origin, as for certain lines given by the alloy FePt[5]. This is possible because at high temperatures the alloy CdMg is hexagonal[6], and the structure we are concerned with is formed by transformation at a lower temperature. The two lines are near the position of the line $10\bar{1}0$ given by the close-packed hexagonal structure, and so we may guess that the structure is orthorhombic, the indices of the lines being 110 and 200[7].

If this guess is correct, the values of the reciprocal constants a^* and b^* are directly deducible, and since these do not correspond in any simple way to the value given by the other line considered, we may deduce that this line is 002. The three reciprocal constants thus obtained were adequate to explain all the lines on the X-ray photograph. (The actual photograph from which the values of $\sin^2\theta$ were derived was obtained from a specimen having smaller grain size; the lines, although still spotty, were much more nearly uniform than those illustrated in the drawing.) While the more systematic methods referred to would no doubt also have led to this result, the methods just described must be many times faster.



Diagrammatic representation of part of powder photograph of CdMg

The unit cell has dimensions $a = 5{\cdot}24$ A., $b = 3{\cdot}22$ A., $c = 4{\cdot}97$ A., and, from comparison with the close-packed hexagonal structure it contains two atoms of cadmium and two of magnesium. The structure is isomorphous with AuCd[8].

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'Window Fields' in Muscle

The 'membrane', that is, the electric double layer, surrounding the muscle fibre generates no field of forces inside the system. If, however, part of the membrane becomes depolarized, the depolarized part acts, so to say, as a 'window' in the closed system and an electric field is generated. If the depolarization should occur with a sharp border, the maximal intensity of the field in the axis of the fibre would correspond to a field generated between the two plates of a condenser placed at a distance equal to the diameter of the fibre and having the same potential difference as the two sides of the 'membrane'. If the wave of depolarization travels along the membrane, this will have the same effect as if we had pulled electrodes along the axis charged correspondingly. Experiments, performed along this line by St. Hajdu and one of us, show that such a field will actually bring the contractile matter directly to contraction even if the membrane is inoperative.

It is an interesting property of the 'window field' that its time integral is independent of the sharpness of the borderline of the wave of depolarization, and that the time integral of the component of the field parallel to the axis is identical for any point of the cross-section. It is equally noteworthy that the time integral of the component of the field, vertical to the axis, is zero. The parallel component will act as a direct current, the vertical one as an alternating current.

There seems to be thus no 'transmission' of excitation from the membrane to the contractile matter; depolarization and the elicitation of contraction merge into one single physical event.

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A New Blood-Group Antigen

A serum that identifies a new blood-group antigen was obtained from the parturient mother of a baby with erythroblastosis fœtalis. Mrs. Kidd had had five previous pregnancies but no blood transfusions. No previous babies had erythroblastosis fœtalis. She was delivered on April 17, 1950, of a male infant who developed typical erythroblastosis fœtalis, and whose cells gave a positive direct Coombs's test. On routine testing of Mrs. Kidd's serum at that time, it was apparent that it contained a previously unidentified antibody.

Typing tests showed Mrs. Kidd to be *O, CDe/cDE* (R_1R_2), *MsMs, Pp, Le(a−b+), Fy(a−), kk.* Her cells were not agglutinated by her own serum. The baby is *O, CDe/cDE* (R_1R_2), *MSMs, pp, Le(a+b+), Fy(a+), Kk.*

The serum was further tested against the bloods of 210 unrelated persons. Of twenty-one *Kell*-positive bloods, all were agglutinated by the Kidd serum. The presence of anti-*Kell* was later proved. Of the remaining 189, all *Kell*-negative, 146 (77 per cent) were agglutinated. Chi square tests failed to show any serological relation of the new antigen to the antigens of the *ABO, MNS, P, Rh, Lewis* or *Duffy* blood-group systems, or to sex. Insufficient evidence has been obtained as to the relation, or lack of relation, to the *Lutheran* and *Kell* blood-group systems. Further selective absorption studies and family studies will be required.

The new antibody gave specific reactions at 37° C. against red cells suspended in saline, in a titre of 1 : 16. The reactions were no stronger in bovine albumin; but a titre of 1 : 64 was obtained by Coombs's method. On storage, the saline-active component has disappeared, leaving a component active by the Coombs's method. A saline-active component of the anti-*Kell* made it impossible to distinguish *Kell*-positive, *Kidd*-negative bloods.

On the basis of these preliminary tests, it is possible to say that a new blood-group antigen has been identified, present in the red cells of about 77 per cent of Americans. If it is inherited as a dominant, the gene frequency in Americans is approximately 52 per cent. It is proposed to name the new antigen Jk^a (after Mrs. Kidd's son); its inheritance is now being investigated.

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Sweating in Man from the Intradermal Injection of *nor*Adrenaline

It has been generally believed that sweating in man is produced in response to sympathetic nervous activity by the liberation at the termination of the post-ganglionic fibre supplying the sweat gland of acetylcholine[1], the transmitter being different from that liberated by sympathetic fibres supplying other organs, which, until recently, was believed to be adrenaline. However, evidence has accumulated that there is an adrenergic component in sweating in man. Sweating is a prominent feature in patients with phæochromocytomata[2], which were believed to secrete adrenaline. Spontaneous sweating in man is abolished by the adrenolytic agent 'Dibenamine'[3]. The intradermal injection of adrenaline has been shown to produce sweating[4].

Recently, evidence has accumulated that the post-ganglionic sympathetic transmitter is probably *nor*adrenaline[5–9]. Also the ergone predominantly present in phæochromocytomata has been shown to be predominantly *nor*adrenaline[8,10].

It was therefore considered of importance to determine whether the local injection of *nor*adrenaline could produce sweating. The method used for detection of sweat-gland activity was that described by Masao Wada[4]. Briefly, the area of skin to be examined is painted with a 3 per cent iodine in absolute alcohol solution and dried completely; the area is painted again with a mixture of 100 gm. fine starch powder and 100 ml. of castor oil. Sweating is evidenced by the appearance of blue dots at the mouths of the sweat glands.

Adrenaline hydrochloride and *nor*adrenaline bitartrate monohydrate were prepared in dilutions of 10^{-3} to 10^{-6}. A small amount of a saline control solution and the different dilutions of the adrenaline and *nor*adrenaline solutions were injected intradermally in the skin areas prepared as described. Sweating was produced with the dilutions 10^{-3} to 10^{-6} with both the adrenaline and *nor*adrenaline solutions in all of five subjects, and in some cases with a dilution of

10^{-6}. In one subject the investigation was repeated one hour after the subcutaneous administration of 1/75 grains of atropine sulphate, and no alteration in the response was noted, suggesting that the sweating is due to the direct stimulation of the sweat glands by the injected solutions, and that cholinergic fibres do not play a part in its production.

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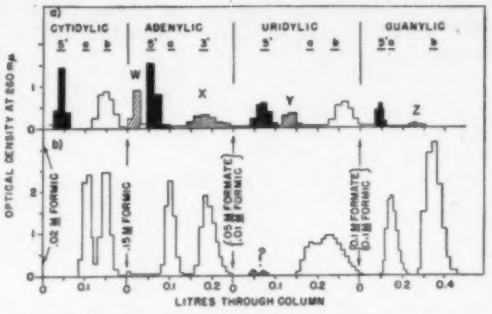
Nucleoside-5′-Phosphates from Ribonucleic Acid

Though the manner in which the four nucleotides of ribonucleic acid are combined in the intact molecule is not completely settled, the data obtained from analyses of the chemical degradation products are most compatible with phosphoryl-group attachments through the C_3 and C_5 positions of the ribose group[1]. The exclusion of C_2 phosphoryl linkages rests principally upon the failure to isolate 5′ nucleotides or the acid-stable ribose-5-phosphate from acid hydrolysates of ribonucleic acid. However, Gulland and Jackson[2], hydrolysing yeast ribonucleic acid with a snake venom containing a phosphodiesterase and a specific 5′ nucleotidase, found 35 per cent of the total phosphate liberated as inorganic phosphate, suggesting that a large number of the phosphoryl groups were attached to the ribose C_2 position. Recently, Schmidt[3], utilizing periodate titrations of ribonuclease-hydrolysed yeast ribonucleic acid, concluded that some nucleotide groups had been linked to positions other than ribose C_3 or C_5 in the original ribonucleic acid. The experiments described below indicate that intact 5′ nucleotides can be isolated from enzymatically hydrolysed calf liver ribonucleic acid.

Calf liver ribonucleic acid, prepared by a technique avoiding the use of alkaline solutions[4], was hydrolysed successively by crystalline ribonuclease and by alkaline intestinal phosphatase in the presence of sodium arsenate to inhibit excessive dephosphorylation of the derived nucleotides, as originally described by Klein[5] for the enzymatic production of deoxyribonucleotides. The reaction was allowed to proceed until about 75–80 per cent of the total titratable phosphoryl groups were released, after which the digestion was stopped by the addition of formic acid to a concentration of 0·1 *N*. The nucleotide products of the digest were then isolated by the anion-exchange procedure described by Cohn[6].

The accompanying diagram shows the ion-exchange elution curve of the nucleotides isolated from the digest. The identification of the 5′ nucleotides indicated on the figure was made chiefly by comparing their properties with those of the corresponding synthetic 5′ nucleotides (we are indebted to Dr. D. M. Brown and Prof. A. R. Todd for generous samples of synthetic guanosine-5′-phosphate, uridine-5′-phosphate and cytidine-5′-phosphate) as follows: (*a*) the ion-exchange elution positions are identical with those of the analogous 5′ nucleotides (and deoxynucleotides) and are readily differentiated from the *a* and *b* isomeric forms[6,7]; (*b*) the spectrophotometric absorption characteristics of the isolated pyrimidine-5′-phosphates show definite differences from those of the *a* and *b* forms, but are exactly those of the corresponding synthetic substances; (*c*) the isolated adenosine-5′-phosphate and muscle adenylic acid were both deaminated at exactly the same rate by a preparation of Schmidt's muscle adenylic acid deaminase[8], whereas adenylic acids *a* and *b* were unaffected by the enzyme; (*d*) a highly specific preparation of bull semen 5′ nucleotidase (kindly supplied by Dr. L. A. Heppel) readily and rapidly dephosphorylated all of the isolated 5′ nucleotides, as well as the synthetic 5′ nucleotides, but was completely inactive towards all *a* and *b* mononucleotides; (*e*) the isolated 5′ adenylic acid contained adenine, pentose (orcinol reaction) and phosphate in a 1 : 1 : 1 proportion. Deoxypentose (diphenylamine reaction) was not present in any of the 5′ compounds nor was acid-labile phosphate (1 *N* hydrochloric acid, 1 hr., 100° C.).



Analyses of (*a*) enzymatic digest, (*b*) alkaline digest of 20 mgm. of calf-liver ribonucleic acid by ion-exchange. Exchanger: 'Dowex-1' (formate form), 200–400 mesh, 7 cm. × 0·88 sq. cm. Influent: formic acid and sodium formate, as shown; 0·6 ml./min.

Enzymatic resynthesis of smaller fragments, rearrangements of mononucleotides to yield the 5′ compounds during the enzymatic hydrolysis and pre-existence of the free 5′ compounds were excluded by the following experiments: (1) a similar enzymatic hydrolysis of ribonucleic acid carried out in the presence of isotopic inorganic phosphate yielded 5′ and 3′ nucleotides containing none of the isotope (nor was arsenate incorporated); (2) incubation of a mixture of the nucleosides or nucleotides with the phosphatase in a phosphate medium resulted in no measurable synthesis of any of the 5′ nucleotides; (3) acid and alkaline hydrolysates yielded neither 5′ nucleotides nor ribose-5-phosphate; (4) ribonuclease alone or ribonuclease followed by alkaline hydrolysis yielded no 5′ nucleotides; these appeared only after phosphatase treatment. Thus, if isomerization during digestion does indeed take place, it must occur at the polynucleotide level.

It is our intention to use ion-exchange chromatography, already responsible for the isolation of many new nucleotides[9] from nucleic acid hydrolysates, to determine the generality of this finding, as well as in the search for hitherto unknown constituents (for example, *W*, *X*, *Y*, *Z* and ? in the diagram).

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Nature of the Activation Process in Enzymatic Reactions

The study of enzyme-catalysed reactions has thrown considerable light on the geometrical factors involved; but little is as yet known concerning the mechanism of the activation process. The experiments reported here were designed to yield information on the transformations which occur during enzyme action.

In the first investigation, carbobenzoxy-L-phenylalanine was incubated with and without chymotrypsin in oxygen-18 water ($H_2{}^{18}O$). In one experiment, crystalline bovine serum albumin was included. Following incubation, the reaction mixture was acidified (*p*H 3); the carbobenzoxy derivative was centrifuged, washed with water, and converted to phenylalanine by hydrogenation in aqueous methanol in the presence of palladium black. After crystallization from water, the amino-acid was decarboxylated at 270–290° in a mixture of diphenylamine and diphenylmethane[1], and the oxygen-18 concentration of the resulting carbon dioxide determined.

Phenylalanine was similarly incubated in oxygen-18 water with and without chymotrypsin; the acidified reaction mixture was taken to dryness, the phenylalanine hydrochloride extracted from the salts with absolute ethanol and the free amino-acid precipitated with pyridine. The results are given in the accompanying table.

Compound	Oxygen-18 (atom per cent excess)
L-Phenylalanine	0·000
Cbz-L-Phenylalanine	0·009
Cbz-L-Phenylalanine + chymotrypsin	0·470
Cbz-L-Phenylalanine + chymotrypsin	0·524
L-Phenylalanine + chymotrypsin	0·028
*Cbz-L-Phenylalanine + chymotrypsin	0·412
*Cbz-L-Phenylalanine + chymotrypsin + 25 mgm. bovine serum albumin	0·392

* 4-hr. incubation.

100 mgm. of Na_2HPO_4 and 41 mgm. of KH_2PO_4 were dissolved in 5 c.c. of $^{18}H_2O$ (1·13 atom per cent excess ^{18}O) and 100 mgm. of carbobenzoxy-L-phenylalanine or 65 mgm. of L-phenylalanine were dissolved in this buffer (*p*H 7·0). Following the addition (where indicated) of 20 mgm. of crystalline chymotrypsin (Armour), the solution was incubated at 37° for 6 hr.

It can be seen that, under the influence of chymotrypsin, the carboxyl group of an N-acyl aromatic amino-acid is activated and the oxygen atoms exchange with those of the medium. The presence of serum albumin has no marked effect. In the absence of enzyme the exchange does not occur. The free amino-acid is apparently not activated by chymotrypsin.

It is of interest that N-benzoyl D- and L-phenylalanine are inhibitors of chymotrypsin[8] (cf. also ref. 3).

In another investigation, the nature of the activation process in transamination reactions was studied. Konikova, Dobbert and Braunstein[4] had previously indicated, on the basis of densimetric estimation of the amount of deuterium passing into the medium, that the deuterium atom of α-deuterio α-amino-acids undergoes exchange with the hydrogen of the solvent water under the influence of glutamic–alanine transaminase. This has now been investigated by direct isolation and analysis. When L-leucine, containing 4·5 atomic per cent excess nitrogen-15 and 82 atomic per cent excess deuterium in the α-position, was incubated for 90 min. with minced pig heart, it lost more than 98 per cent of the deuterium but none of the nitrogen-15[5]. With D-leucine, neither deuterium nor nitrogen-15 was lost. When the L-leucine was incubated with 1 equivalent of α-ketoglutaric acid, more than 98 per cent of its deuterium was lost and the concentration of nitrogen-15 dropped to 3·8 atomic per cent excess[6].

In both cases the interaction of the enzyme and substrate results in an activated structure which can in the first example exchange with the hydroxyl ions, and in the second with the hydrogen ions of the water. In neither case is the usual reaction associated with these enzyme systems observed, namely, the hydrolysis of a peptide bond or the conversion of the amino-acid to the corresponding keto-acid. Were it not for the changes in the isotopic composition of some of the components of the system, no chemical reaction would have been observed. These changes result from the nature of the activated structure, the formation of which precedes and is essential for the complete chemical reaction. The ensuing steps, for example, the hydrolysis of the peptide bond, would then be spontaneous. For this reason it may be appropriate to call the reactions observed *virtual reactions*.

Further work is necessary to elucidate the detailed mechanisms responsible for the observations reported here.

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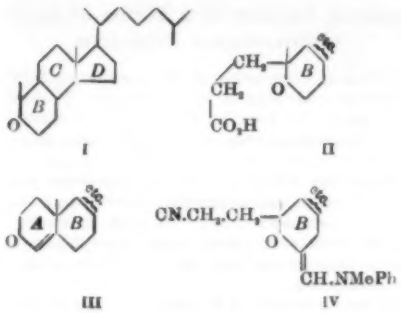
Final Stages of the *A → BCD* Route to Cholesterol

The ketone (I), termed Inhoffen ketone[1], has been obtained from cholestenone by improved methods. When pure, it has a melting point of 52°; it was originally described as an oil (semicarbazone, m.p. 225°, which we confirm) and was crystallized in this laboratory by R. P. A. Sneeden (m.p. 42°).

The Inhoffen ketone might well have been convertible to cholestenone by direct condensation with diethylaminobutanone methiodide under suitable conditions. However, this reaction did not succeed,



I II

III IV

although it gave good results with *cis*-1-methyl-2-decalone[2]. The cause is the *trans*- junction of rings *B* and *C*, and a similar difficulty was encountered with *trans*-1-methyl-2-decalone. This obstacle was surmounted by protecting the methylene group adjacent to carbonyl, when the sluggish process can be forced by more vigorous conditions. Our first objective was, however, the Windaus acid (II), because this has already been converted into cholestenone[3] and hence into cholesterol (Ruzicka, Birch, Dauben).

The hydroxymethylene derivative of the Inhoffen ketone was condensed with methylaniline[4] and the product with acrylonitrile in the presence of 'Triton B' to give IV. After hydrolysis with acid and later with alkali, the authentic Windaus acid (II) could be separated and purified. The identity with the acid from cholestenone was confirmed by undepressed mixed melting point and by comparison of rotatory power and X-ray diffraction patterns of the crystals. Mrs. D. Crowfoot Hodgkin kindly carried out the latter experiments and reports that the two specimens submitted to her are identical.

Thus the Inhoffen ketone is a substance that can be transformed into cholesterol. We now intend to dehydrogenate ring *B* of this ketone and to attempt a junction with the *BCD* tricyclic ketones already synthesized in this Laboratory[5].

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Occurrence of Asperuloside in *Daphniphyllum macropodum* (Euphorbiaceæ) and a closely related Glucoside in *Monotropa hypopitys* Walt. (Pyrolaceæ)

As knowledge of the chemical constitution of plant products extends, types of substances, and individual substances, which were formerly thought to be characteristic of certain taxonomic divisions of plants, are found to occur in divisions, which, on other grounds, are considered to be unrelated. The glucoside asperuloside, first isolated by Hérissey[1], has hitherto been regarded as a characteristic product of plants of the family Rubiaceæ and has been isolated from many of its species. It will be of interest to the student of chemical taxonomy that, in the course of a study of asperuloside, this glucoside has been isolated from *Daphniphyllum macropodum*, which is a Chinese plant of uncertain affinity, placed in the family Euphorbiaceæ, and that a very similar glucoside occurs in the uncommon saprophytic plant *Monotropa hypopitys* Walt., which is placed in the Ericales, family Pyrolaceæ.

1·8 gm. of asperuloside was isolated from 315 gm. fresh leaves of *D. macropodum*, kindly supplied by Mr. J. Gilmour, director of the Royal Horticultural Society's Garden. This material has the following constants: m.p. 126°–129°, $[\alpha]_D^{18} - 200°$; C, 50·7 per cent; H, 5·6 per cent. The constants of an authentic sample of asperuloside prepared from *Rubia tinctorum* were: m.p. 125°–127°, $[\alpha]_D^{18} - 204°$; C, 50·9 per cent; H, 5·7 per cent. A mixture of the two preparations melted at 126°–129°. The glucoside from *Daphniphyllum* crystallized on seeding with the authentic material, and both substances ran at the same rate in two different solvent mixtures on filter-paper chromatograms.

Asperuloside has a number of highly specific colour reactions which make it very easy to detect. These are also given by a glucoside prepared from *Monotropa hypopitys*, which is identical with "monotropéine" isolated from this plant by Bridel[2]. The following properties described by Bridel distinguish it from asperuloside; it is acid to litmus, whereas asperuloside is neutral, decomposes sodium carbonate and has the following constants: m.p. 175°, $[\alpha]_D - 130·4°$.

I am indebted to Mr. E. J. H. Corner, of the Botany School, Cambridge, for suggesting the investigation of *Daphniphyllum macropodum*, and to Dr. R. Hill for his close interest in this work.

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Melting Points of Mixtures of Cetyl Caprate with Lauryl Myristate

The work of Oldham and Ubbelohde[1] suggested that the melting point of mixtures of dipolar compounds may be much lower than predicted by the Le Chatelier – Schröder (or Hildebrand) equation[2] if one uses components which are able to crystallize in a composite lattice but are sufficiently different in chain-length to lead to the formation of a defective lattice. The formation of lattice flaws is made possible

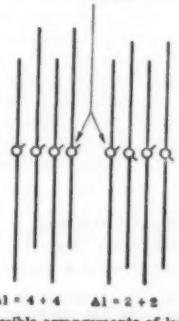

Fig. 1. Alternate possible arrangements of lauryl myristate and cetyl caprate in composite crystal lattices
Δl = size of gaps (in number of C-atoms) in the lattice

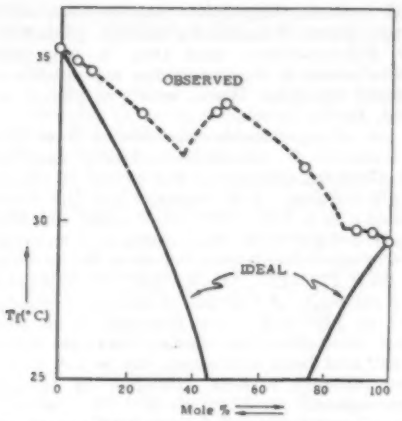

Fig. 2. Melting-point curves of mixtures of lauryl myristate (m.p. 35·3° C.) and cetyl caprate (m.p. 29·4° C.)

by the arrangement of the dipoles of all components in continuous dipole sheets throughout the crystal. Oldham and Ubbelohde proved the usefulness of this picture for mixtures of various long-chain ketones. In order to test the applicability of this hypothesis to mixtures of esters, a series of mixtures was prepared from two esters (cetyl caprate and lauryl myristate) which happened to be available in better than 95 per cent purity. The over-all chain-length of these esters is identical; but their arrangement along a dipole sheet would lead to a high concentration of lattice flaws (Fig. 1). Judging by Oldham's work, the relative concentration of lattice flaws in either configuration should be sufficient to promise a substantial reduction in lattice stability, that is, in melting point.

This expectation was not fulfilled by the experimental data, shown in Fig. 2. Rather to the contrary, there are even indications of a maximum in the melting-point curve, in addition to the indications of formation of solid solution. The solid-solution-like behaviour suggests that—as has been indicated by dielectric loss measurements[2]—the ester dipole interaction is too weak to lead to the formation of dipole sheets against the forces of the 'horror vacui', while the very much stronger ketone dipole interaction observed by Oldham and Ubbelohde is well able to do so. Instead, the ester mixtures behave more like a mixture of normal long-chain hydrocarbons, and apparently form solid solutions involving continuous (flawless) parallel arrangement of all molecules in the crystal lattice. The maximum may simply reflect the formation of a crystal modification ('compromise lattice') unrelated to the crystal structure of either component[4]. Proof for this explanation could only be obtained by X-ray diffraction measurements. The occurrence of similar solid-solution phenomena in crystallized chain co-polyesters[5] points to the generality of the observations reported.

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Frequency Factors in a Series of Similar Unimolecular Reactions

Our present knowledge of the frequency factors of unimolecular reactions is very limited. Polanyi and Wigner[1] were the first to elucidate the meaning of this entity and their treatment suggested a magnitude of the order of 10^{13} sec.$^{-1}$ for the frequency factors of unimolecular reactions. This conclusion was confirmed by many experimental observations and by further theoretical studies[2]. We lack, however, more precise information about the dependence of the frequency factors on molecular structure and on the type of reactions.

There are several difficulties in assembling the data required for this purpose. Many reactions, originally claimed as unimolecular, have been shown by later investigations to be complex processes, often involving a chain. Further difficulty arose from the fact that frequently the character of a reaction is changed with temperature. For example, a process which for all practical purposes is unimolecular in character at one temperature may be accompanied by a heterogeneous reaction at lower temperature, or by a chain at higher temperature. In consequence, the activation energy of such a unimolecular reaction would be estimated in an erroneous way, and since the computation of the frequency factor requires the determination of the activation energy, the error in the latter causes considerable error in the former.

The absolute values of the frequency factors of unimolecular reactions reported in the literature are subject to appreciable uncertainty, caused by the difficulties mentioned above, and in our opinion an error by a factor of 2–3 might be quite common. It seems, therefore, that the available data are not sufficiently accurate to enable us to draw any conclusions regarding the factors affecting the magnitude of frequency factors. However, one regularity may be claimed, namely, the frequency factors seem to remain constant for a series of similar processes. For example, it was shown experimentally[3] that the frequency factors remain constant and equal to about 2×10^{13} sec.$^{-1}$ for a series of unimolecular dissociation processes of the type:

$$RH \rightarrow R + H,$$

R being $C_6H_5.CH_2$, p-$CH_3.C_6H_4.CH_2$, m-$CH_3.C_6H_4.CH_2$, and o-$CH_3.C_6H_4.CH_2$.

The constancy of frequency factors for such a series may be demonstrated by a more exact method. It is extremely improbable that, in a series of similar decompositions, the variation in activation energy would be just balanced by the variation in the frequency factor, thus leaving unchanged the rate constants of the reactions. On the other hand, it was observed that the rate constants of decomposition of toluene, m-xylene[3], p-, m- and o-fluoro-toluene[4], and γ-picoline[3] were identical within 25 per cent (see Table 1). It was demonstrated that all these reactions were of the same type, namely,

$$RH \rightarrow R + H.$$

The activation energy in these processes should be equal to the respective C—H bond dissociation energy, and it seems that the latter is constant for all the compounds listed above (see ref. 4). Thus, the equality of all these rate constants is, in our opinion, the

Table 1. $RH \rightarrow R + H$

Compound	Rate constant interpolated to 804° C. 10^5 sec.$^{-1}$
Toluene	3·8
m-Xylene*	4·4
p-Fluoro-toluene	3·4
m-Fluoro-toluene	3·1
o-Fluoro-toluene	3·3
p-Picoline	4·3

* The rate is divided by the statistical factor of 2.

strongest argument in favour of the assumption of the constancy of the frequency factors in a series of similar decompositions.

Recent studies of the pyrolysis of substituted benzyl bromides[6] provide additional evidence supporting this argument. It was shown that the rate-determining step in the pyrolysis of benzyl-bromide and its derivatives is a unimolecular homogeneous dissociation process :

$$C_6H_5.CH_2Br \rightarrow C_6H_5.CH_2 + Br,$$

and it was found that the rate of decomposition is nearly constant (within 25 per cent) for benzyl bromide, *m*-xylyl bromide, *p*- and *m*-chloro-benzyl bromides, and *p*- and *m*-bromo-benzyl bromides (see Table 2).

Table 2. $RBr \rightarrow R + Br$

Compound	Rate constant interpolated to 527° C. 10^5 sec.$^{-1}$
Benzyl bromide	46
m-Xylyl bromide	47
m-Chloro-benzyl-bromide	52
p-Chloro-benzyl-bromide	60
m-Bromo-benzyl-bromide	56
p-Bromo-benzyl-bromide	56

Some observations might be regarded as a generalization of the above rules to other series of similar reactions. Thus C. K. Ingold and W. S. Nathan[7] estimated the activation energies for the hydrolysis of various substituted benzoic esters. The graph of the estimated activation energies versus $\log k$ (k being the rate constant of hydrolysis) gives a straight line, proving that the frequency factors remain constant throughout the whole series. These authors also directed attention to the results obtained by E. G. Williams and C. N. Hinshelwood[8] for the kinetics of benzoylation of various substituted anilines. A similar plot of E versus $\log k$ obtained by the latter authors gave a straight line which was parallel to that obtained by Ingold and Nathan. The idea of the constant frequency factors in a series of kindred reactions was developed further by L. P. Hammett[9], who devised a system of ρ- and σ-factors ; ρ represents an entropy change constant for the same type of reaction, and σ represents the change in activation energy characteristic for each member of the series. It has to be emphasized, however, that the regularities discussed above were observed in liquid-phase reactions, and one has to be careful in using them as a support for argument which applies to gas-phase reactions.

Attention must be directed to a relationship frequently assumed between the activation energy of a process and its frequency factor. This relationship is justified only for such series of reactions in which the variable parameter affects the reacting centre. For example, by varying the solvent in which some process takes place, one affects both the energy and the entropy of activation, and both are changed in the same direction. For the gas reactions, however, the relationship between the activation energy and the frequency factor seems to be fortuitous. Due to technical limitations, we are forced to measure rates of reactions in a comparatively narrow range ; in consequence, the accumulated experimental material sometimes indicates the existence of a relationship between two entities which has no real existence.

We conclude that the frequency factors of unimolecular dissociation processes occurring in the gas phase seem to be unaffected by the variation in the structure of a molecule which does not affect the reacting centre ; but that it depends on the type of reaction and on the structure of the reacting centre.

Thanks are due to Prof. M. G. Evans for helpful discussions.

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Modified Carbobenzyloxy Groups in Peptide Synthesis

The 'carbobenzyloxy' method of peptide synthesis[1] has proved its value in many important syntheses. Nevertheless, the practical difficulties still encountered in this field suggest that improved protecting groups should still be sought. We have recently been examining benzyl chloroformates substituted in the benzene ring, and other closely related compounds, in the hope that the amino-acid and peptide derivatives might crystallize more readily and that other properties, such as stability and ease of removal of the protecting group, might differ in such a way as to increase the scope of this method of synthesis.

α-Naphthyl carbinol reacted with phosgene to give a product which was coupled with glycine in the normal manner, giving carbo-α-naphthylmethoxyglycine (found : C, 65·2 ; H, 5·2 ; N, 5·3. $C_{14}H_{13}O_4N$ requires : C, 64·86 ; H, 5·02 ; N, 5·41 per cent), but this material began to decompose just below its melting point, liquefying at 136°. The theoretical amount of carbon dioxide was evolved on hydrogenation. The acid chloride was prepared by the action of phosphorus pentachloride and coupled with glycine ethyl ester, but difficulty was encountered in the purification of the product and of the carbo-α-naphthylmethoxyglycylglycine obtained by saponification, and no further derivatives were prepared.

p-Tolyl carbinol yielded a liquid chloroformate which was coupled in the normal manner to give carbo-*p*-tolyloxyglycine (m.p. 93°), and carbo-*p*-tolyloxyglycine ethyl ester (m.p. 38°) (found : C, 62·3 ; H, 6·9. $C_{13}H_{17}O_4N$ requires : C, 62·1 ; H, 6·8 per cent). Treatment of the ester with hydrazine gave carbo-*p*-tolyloxyglycyl hydrazide (m.p. 120°) (found : C, 55·7 ; H, 6·4. $C_{11}H_{16}N_3O_3$ requires : C, 55·7 ; H, 6·3 per cent). These compounds appear to offer little advantage over the corresponding carbobenzyloxy derivatives.

p-Bromobenzyl chloroformate was then prepared from *p*-bromobenzyl alcohol, as a stable low-melting crystalline solid. With glycine it gave carbo-*p*-bromobenzyloxyglycine (m.p. 139°) (found: C, 41·8; H, 3·3. $C_{10}H_{10}O_4NBr$ requires: C, 41·7; H, 3·5 per cent); treatment of the latter with phosphorus pentachloride followed by coupling with glycine ethyl ester gave carbo-*p*-bromobenzyloxyglycylglycine ethyl ester (m.p. 125°) in nearly theoretical yield (found: C, 45·3; H, 4·5. $C_{14}H_{17}O_5N_2Br$ requires: C, 45·04; H, 4·56 per cent). With hydrazine, carbo-*p*-bromobenzyloxyglycylglycyl hydrazide was obtained (m.p. 180°) (found: C, 40·5; H, 4·3. $C_{12}H_{15}O_4N_4Br$ requires: C, 40·12; H, 4·18 per cent). With glycine ethyl ester, *p*-bromobenzyl chloroformate gave carbo-*p*-bromobenzyloxyglycine ethyl ester (m.p. 74°), which yielded a hydrazide (m.p. 148°) (found: C, 39·9; H, 3·5. $C_{10}H_{12}O_3N_2Br$ requires: C, 39·7; H, 3·85 per cent). Hydrogenation removed the protecting group from carbo-*p*-bromobenzyloxyglycine in the normal manner. All these materials have melting points higher than the corresponding carbobenzyloxy compounds, and in general they crystallize with greater ease. Derivatives of other amino-acids are being prepared.

Other modifications of the carbobenzyloxy group are being examined, but meanwhile the use of *p*-bromobenzyl chloroformate may be found advantageous in peptide synthesis.

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Epidermal Mitotic Activity and Oxygen Tension

The effects of anaerobic conditions on mammalian epidermis were first studied by Medawar[1], who developed an elegant technique for showing that this tissue can survive by anaerobic glycolysis alone, but that cell movement and division depend on "respiratory activity in the narrow sense". These conclusions, which apply to the rabbit, have now been confirmed and elaborated in the case of the mouse. A technique has been devised, using standard Warburg equipment, for the maintenance of ear epidermis from adult male mice in a phosphate-buffered saline with added glucose.

Five fragments of ear epidermis (*c.* 2·5 mm. × 5·0 mm.) were immersed in 4 ml. saline medium in each flask, the side arm containing 0·016 mgm. colchicine in 0·04 ml. solution. The manometers were gassed with oxygen, nitrogen, or oxygen/nitrogen mixtures as required, and the flasks were maintained at 38° C. After one hour, when all the mitoses originally present were judged to have passed the metaphase, the colchicine was tipped into the main compartment. The incubation was then continued for a further four hours, when the tissue was fixed for sectioning. The results are shown in Table 1.

Table 1. The average numbers of mitoses arrested by colchicine in unit lengths (1 cm.) of sections (7 μ thick) of mouse ear epidermis after 4 hr. incubation at 38° C. in phosphate-buffered saline with added glucose. Each figure is the average of 10 observations

Gas phase:					
100% N_2	80% N_2/20% O_2	60% N_2/40% O_2	40% N_2/60% O_2	20% N_2/80% O_2	100% O_2
0·4 ± 0·10	2·2 ± 0·26	3·9 ± 0·27	5·5 ± 0·33	6·8 ± 0·34	8·3 ± 0·49

These figures indicate a direct linear relationship between epidermal mitotic activity and oxygen tension, and coincident observations on oxygen uptake (without colchicine) have confirmed that with increased oxygen tensions increased quantities of oxygen are absorbed (Table 2).

Table 2. $Q(O_2)$ of mouse-ear epidermis determined during 4 hr. incubation at 38° C. in phosphate-buffered saline with added glucose ($Q(O_2)$ = μl. oxygen consumed/mgm. dry wt./hr.). Each figure is the average of 8 observations

Gas phase:		
80% N_2/20% O_2	40% N_2/60% O_2	100% O_2
1·18 ± 0·05	1·52 ± 0·06	1·83 ± 0·07

Evidently a direct linear relationship also exists between oxygen consumption and oxygen tension.

Confirmation is thus provided for the theory already advanced that epidermal mitotic activity depends on the energy derived from the aerobic metabolism of glucose[2,3]. If this is so, then by adding to the saline medium known catalysts of the tricarboxylic acid cycle, it should be possible to increase the oxygen consumption and hence the mitosis rate. The results of an experiment in which 0·02 *M* sodium glutamate was present in the saline medium are shown in Table 3.

Table 3. The influence of 0·02 *M* sodium glutamate on the numbers of mitoses arrested by colchicine in 4 hr. and on the $Q(O_2)$ of mouse-ear epidermis incubated at 38° C. in phosphate-buffered saline with added glucose and a gas phase of oxygen

Numbers of mitoses (5 observations)		$Q(O_2)$ (8 observations)	
without glutamate	with glutamate	without glutamate	with glutamate
6·7 ± 0·60	10·0 ± 0·75	1·83 ± 0·07	2·40 ± 0·13

It has already been established that glucose and oxygen exert their action on mitosis at a time immediately prior to the prophase, and that they are without effect once the prophase has begun[4]. This pre-prophase is evidently a critical time in the physiology of mitosis, and the name of 'antephase' has been suggested for it. The evidence so far available suggests that the energy required for mitosis must be built up in the antephase, and that once a division begins it can continue to completion in almost any circumstances short of the death of the cell. On one hand, the numbers of mitoses developing can be increased by stimulating the rate of energy production from glucose oxidation, while, on the other, they can be depressed by anaerobic conditions and by such known inhibitors of cellular metabolism as cyanide, fluoride, and dinitrophenol[5]. However, none of those substances which stimulates or depresses mitotic activity in this way appears to have any substantial effect on the course of a cell division once it has begun.

A full account of the techniques devised for this work and of experiments with catalysts and inhibitors will be published in due course.

W. S. Bullough
Monica Johnson

Departments of Zoology and Biochemistry,
University, Sheffield 10.
Nov. 17.

[1] Medawar, P. B., *Quart. J. Micr. Sci.*, **83**, 27 (1947).
[2] Bullough, W. S., *J. Exp. Biol.*, **26**, 83 (1949).
[3] Bullough, W. S., *J. Endocrinol.*, **6**, 350 (1950).
[4] Bullough, W. S., *Exp. Cell Res.*, **1**, 497 (1950).
[5] Needham, J., "Biochemistry and Morphogenesis" (Cambridge, 1942).

Habitat of *Balanus amphitrite* var. *denticulata* in Britain

In a recent communication, M. W. H. Bishop[1] suggests that since *Balanus amphitrite* of a variety conforming to Broch's var. *denticulata* has been found on the southern coasts of Britain, this represents the northern limit of distribution of this tropical and Mediterranean variety. We should like to add some further detail to the existing records and to contribute additional ones which point to some modification of Bishop's general conclusion.

The persistence of this species at Shoreham, where it was first collected by Dilwyn John in 1937 together with a new species of *Hydroides* described by Monro[2], appears to be due entirely to the entry of warm water from condensers of the local power station. This warmed water flows through a cooling pond some 10,000 sq. yd. in area, and is largely retained here and in the adjacent Shoreham harbour canal (Fig. 1), where the water-level rises and falls some 2 ft. owing to the opening of locks (*G*, Fig. 1) on spring and neap tides. *B. amphitrite* occupies the zone of this tidal fluctuation in considerable numbers (500–1,000 per sq. metre) but extends below it only to a limited extent owing to competition by other sessile organisms, for example, *Botrylloides*, *Bugula neritina* and sessile diatoms. Small numbers of healthy individuals occur as far away as the lock gates of the harbour. The zone of settlement during summer extends into the tidal arms of the estuary on floating buoys, etc., and it has been recorded on experimental panels on the Palace Pier, Brighton, some three miles to the east. Nevertheless, these settlements outside the canal are not permanent, examinations in early spring showing many dead shells and scars. There is no evidence elsewhere along the south or south-east coasts of Britain of any persistent or considerable settlement of the species. Temperatures have been recorded regularly within the cooling pond, which is normally uniform within 1° C., and the lowest record (winter 1946–47) was 7° C. In cold weather the higher load on the station leads to a greater transfer of heat to the circulating water and so to more equable conditions than prevail outside. Breeding in this very limited population occurs regularly every year and is ample to maintain the species (1947–50). Fertilizations occur during March–September and settlements during May–August. In summer, temperatures of 25° C. or higher are commonly encountered.

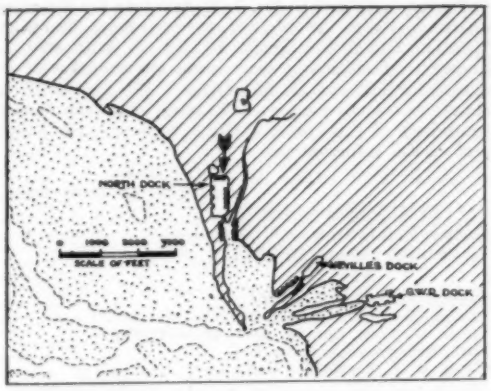


Fig. 2. Settlement of *Balanus amphitrite* at Llanelly. Condenser discharge indicated by arrow. Settlements marked as in Fig. 1

Records in the Plymouth area show a similar phenomenon; we have taken specimens on several occasions on piles in the immediate vicinity of the power station discharging below Laira Bridge in the River Plym but not elsewhere. The species is, however, less abundant locally, though judged from Bishop's observations rather more widespread, than at Shoreham. This we believe to be due to more rapid dispersal of the warmed effluent, and milder winter temperatures in the sea outside.

Two additional records have been obtained, at Llanelly and Swansea (August 1949). At Llanelly a warmed discharge enters the North Dock; *Balanus amphitrite* was found here and in Neville's Dock, a blind basin 600 yd. distant (Fig. 2). At Swansea it occurs on buoys, piles, etc., in the Queen's Dock, where again the water is artificially warmed. It does not appear to be present elsewhere along the coast. In all specimens examined the labrum indicates that the var. *denticulata* of Broch[3] is present.

Thus the habitat of *Balanus amphitrite* in Britain is localized and artificial; the species is in no sense naturally established. The spread of *Elminius modestus*, which has now extended its range north of the Humber to the Blyth Estuary[4] on the east coast and into the Solway and Loch Ryan on the west[5], offers a remarkable contrast.

Both *Elminius modestus* and *Balanus amphitrite* are sometimes found infected by *Hemionyscus balani*, the incidence of infection in some areas of the South Devon and South Wales coast being greater than 50 per cent.

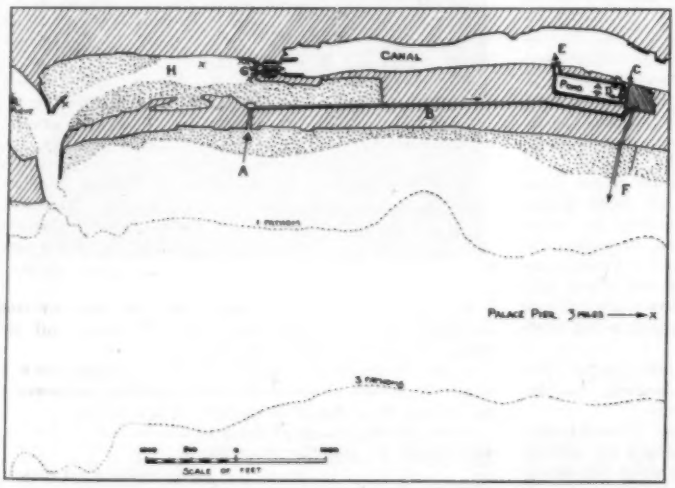


Fig. 1. Shoreham Harbour Canal. Water from the sea is pumped from *A* along the duct *B*, where it joins water from the canal entering at *C* and is passed into the condensers. Warm effluent is discharged both out to sea at *F* and into the cooling pond at *D*, whence it re-enters the canal by a conduit *E*. Persistent settlements indicated by thick broken lines. Transient settlements marked *X*. Water movement indicated by arrows

We are indebted to Dr. J. P. Harding for directing our attention to the original specimen from Shoreham Harbour and to the British Electricity Authority for giving us facilities in examining the vicinity of its condenser effluent at Shoreham. We also wish to thank the Dockmaster at Llanelly and the Superintendent of the Queen's Dock, Swansea, for access and useful information.

D. J. Crisp
A. H. N. Molesworth
I.C.I. Paints Division,
Marine Paints Research Station,
Cumber House, Brixham.
Nov. 13.

[1] Bishop, *Nature*, **165**, 409 (1950).
[2] Monro, *Ann. and Mag. Nat. Hist.*, (ii), **1** (1938).
[3] Broch, H., *Trans. Zool. Soc. Lond.*, **22**, 133 (1927).
[4] Bull, H. (private communication).
[5] Crisp, D. J. (unpublished observations).

Effect of Gamma-BHC Seed Dressings on the Germination of Cereals

During the development of the combined fungicidal/insecticidal seed dressing 'Mergamma', containing organomercurial and gamma benzene hexachloride, it became apparent that levels of gamma benzene hexachloride on the seed, safe in practical tests in the field and in box tests in soil, were markedly phytotoxic in conventional germination tests in sand or on damp filter-paper. This communication gives a brief summary of an extensive programme of work on this aspect with wheat, barley and oats.

(1) In the field, grain treated with gamma benzene hexachloride and sown at two to four bushels per acre germinated and grew entirely satisfactorily provided excessive dosage was avoided. 500 parts per million of the chemical on the seed gave no appreciable check to emergence and growth. 500–1,000 p.p.m. sometimes slightly checked early growth; the effect was small and disappeared by the fifth or sixth week; yields were not affected. Doses much higher than 1,000 p.p.m. did not invariably check emergence and growth.

Other results from Canada and the United States indicated that 500–1,000 p.p.m. could be safely used at seeding-rates lower than two bushels per acre.

(2) In box tests with soil, the germination of seed which had been treated with gamma benzene hexachloride at 500 p.p.m. or less was not adversely affected by storage for twelve months.

(3) In germination tests on damp filter paper or in sand at doses of 250–500 p.p.m., most seeds germinated normally, even if rather slowly in some instances. Abnormal effects on growth, varying considerably in degree, were also observed. These consisted of checking and thickening of the shoot and characteristic clubbing of the primary roots. Even when these effects were severe, secondary roots were produced in the normal manner.

As doses were increased above 500 p.p.m. the effects became more pronounced, leading to the eventual suppression of normal growth.

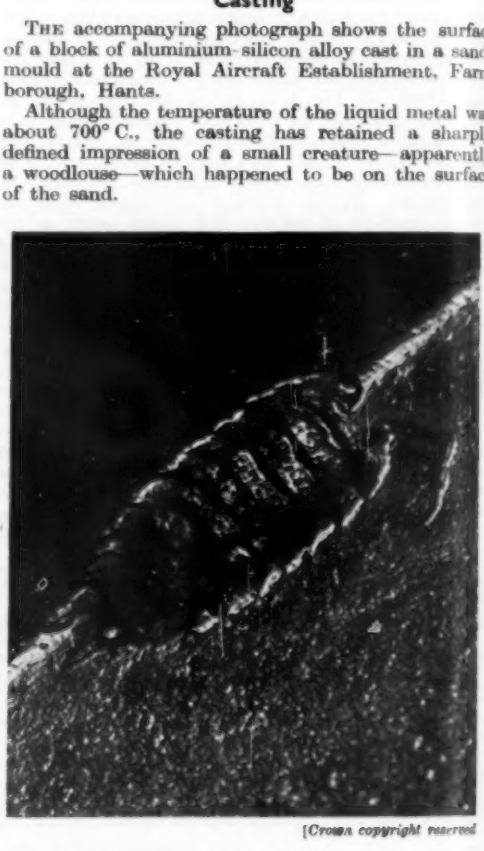
The amount of gamma benzene hexachloride necessary for control of wireworm attack on wheat, barley and oats in the field is of the order of one ounce per acre, giving about 500 p.p.m. and 250 p.p.m. at sowing-rates of two bushels and four bushels per acre respectively. These levels are satisfactory in the field, but are in the range that causes abnormality in sand or filter-paper germination tests. Seed-dressings incorporating gamma benzene hexachloride are coming into general use, and seed may be submitted to standard germination tests after treatment. In such cases the appearance of abnormalities in these tests will not necessarily imply unsuitability of the seed for use in the field.

H. R. Jameson
I. W. McC. Callan
Hawthorndale Laboratories,
Imperial Chemical Industries, Ltd.,
Bracknell, Berks.
Nov. 15.

Imprint of a Crustacean in an Alloy Casting

The accompanying photograph shows the surface of a block of aluminium–silicon alloy cast in a sand-mould at the Royal Aircraft Establishment, Farnborough, Hants.

Although the temperature of the liquid metal was about 700° C., the casting has retained a sharply defined impression of a small creature—apparently a woodlouse—which happened to be on the surface of the sand.



[Crown copyright reserved

To form this concavity the metal must have chilled immediately on contact with the creature, no remains of which could be found.

I felt these facts would be worth putting on the scientific record because of their possible application to the study of fossil formation in hot rocks.

I am grateful to the Editor of the *R.A.E. News* for permission to use the photograph.

Chapman Pincher
Daily Express,
Fleet Street,
London, E.C.4.
Feb. 19.

FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Tuesday, March 27

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, 26 Portland Place, London, W.1), at 6.30 p.m.—Mr. D. A. J. Maddock: "Magnetic Amplifiers".

Wednesday, March 28

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Dr. W. J. Martin: "A Comparison of the Trends of Male and Female Mortality".

BRITISH IRON AND STEEL RESEARCH ASSOCIATION (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr. U. R. Evans, F.R.S.: "Fundamental Studies of Corrosion and their Importance to the Engineer".*

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY, CHEMICAL SECTION (at the Portico Library, Mosley Street, Manchester), at 5.45 p.m.—Dr. J. W. Baker: "Chemical Curricula in the Universities To-day".

SOCIETY OF CHEMICAL INDUSTRY, NUTRITION PANEL of the FOOD GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.15 p.m.—"Factors in Distribution affecting the Quality and Nutritional Value of Foodstuffs", 3, "Fruit and Vegetables".

SOCIETY OF CHEMICAL INDUSTRY, BIRMINGHAM SECTION of the CHEMICAL ENGINEERING GROUP (at the University, Edmund Street, Birmingham), at 6.30 p.m.—Mr. A. H. Loveless: "Relation of the Chemical Engineer to the Chemist and Production Engineer in Industry".

INSTITUTION OF ELECTRONICS, NORTH-WESTERN BRANCH (in the Reynolds Hall, College of Technology, Manchester), at 7 p.m.—Mr. A. Green: "Some Uses of Electrical Capacity in Industrial Measurement".

CHEMICAL SOCIETY, IRISH REPUBLIC SECTION (in the Chemistry Department, University College, Dublin), at 7.45 p.m.—Prof. T. S. Wheeler: "William Higgins (1763–1825)".

Thursday, March 29

PHYSICAL SOCIETY, OPTICAL GROUP (in the Small Physics Lecture Theatre, Imperial College of Science and Technology, Imperial Institute Road, London, S.W.7), at 2.30 p.m.—Tenth Annual General Meeting; at 2.45 p.m. (in the Physics Department)—Scientific Papers.

BRITISH INSTITUTION OF RADIO ENGINEERS, LONDON SECTION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 6.30 p.m.—Dr. J. B. Birks: "Nuclear Scintillation Counters".

Thursday, March 29—Tuesday, April 3

BRITISH PSYCHOLOGICAL SOCIETY (at The University, Liverpool).—Annual General Meeting.

Thursday, March 29—Saturday, March 31

PHYSICAL SOCIETY (in the New Arts Theatre and in the Department of Physics, University College, Swansea).—Symposium on "Some Aspects of Discharge Physics".

Friday, March 30

INSTITUTION OF MECHANICAL ENGINEERS (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Annual General Meeting.

PLASTICS INSTITUTE (at the Engineers' Club, Albert Square, Manchester), at 6.45 p.m.—Mr. H. A. Nancarrow: "Rheology".

ROYAL PHOTOGRAPHIC SOCIETY, KINEMATOGRAPH SECTION (at 16 Prince's Gate, London, S.W.7), at 7 p.m.—Sir Robert Watson-Watt, F.R.S.: "Operational Research in the Film Industry".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (Grade III) IN GEOGRAPHY—The Secretary, The University, Birmingham 3 (March 31).

CHEMISTS at a Ministry of Supply research and development establishment in the London area: SENIOR SCIENTIFIC OFFICER or SCIENTIFIC OFFICER (Ref. F.129/51A), (*a*) ANALYTICAL CHEMIST with experience in microbiology and physical methods, (*b*) PHYSICAL CHEMIST or PHYSICIST for work on surface phenomena and the investigation of the properties of metallic films and coatings, (*c*) PHYSICAL CHEMIST or PHYSICIST for work on the determination of physical properties or in the preparation of novel ceramic materials; EXPERIMENTAL OFFICER or SENIOR EXPERIMENTAL OFFICER (Ref. F.130/51A), (*a*) CHEMIST or CHEMICAL ENGINEER with experience of the control of gases on an industrial scale, (*b*) CHEMIST with experience of gas analysis, (*c*) CHEMISTS experienced in factory development work, (*d*) PHYSICAL CHEMIST or PHYSICIST with interest in work on ceramic materials—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 31).

GRADUATE PHYSICIST to take charge of works instrumentation in the Birmingham District Works—The Divisional Manager, West Midlands Gas Board, Gas Offices, Edmund Street, Birmingham 3 (March 31).

MECHANICAL ENGINEERS (Experimental Officer grade) at a Ministry of Supply design establishment in the south of England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.155/51A (March 31).

METALLURGISTS at Ministry of Supply research establishments in or near London: SCIENTIFIC OFFICERS (Ref. F.206/51A), (*a*) PHYSICAL METALLURGIST with research experience in metallography, (*b*) METALLURGIST with research experience particularly in connexion with the hot and cold processing of metals; EXPERIMENTAL OFFICER or ASSISTANT EXPERIMENTAL OFFICER (Ref. F.207/51A), (*a*) preferably with experience in a research field, of the casting and working of metals, (*b*) with experience in a research field, of electro-deposition, or investigation of the properties of metallic films and coatings—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (March 31).

PHYSICISTS and ELECTRICAL ENGINEERS (Senior Scientific Officer and Experimental Officer grades) at Ministry of Supply experimental and development establishments, for work on outdoor instrumentation—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting A.95/51A (March 31).

PROFESSIONAL ENGINEERS in many departments of the Civil Service for a wide variety of engineering duties—The Secretary, Civil Service Commission, Trinidad House, Old Burlington Street, London, W.1, quoting No. 3225 (March 31).

PROFESSOR OF PHYSIOLOGY at the University of Malaya—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (March 31).

RESEARCH ASSISTANT IN THE DEPARTMENT OF CHEMISTRY, University College, Dundee, to undertake work sponsored by the Department of Scientific and Industrial Research on the thermodynamics of solutions—The Secretary, The University, St. Andrews (March 31).

RESEARCH ASSISTANT (with an honours degree in physics) IN THE DEPARTMENT OF TEXTILE INDUSTRIES—The Registrar, The University, Leeds 2 (March 31).

SCIENTISTS (honours graduates with experience in medical or veterinary research and specialized in bacteriology, biochemistry, biophysics, immunology, virology or pathology) at a Ministry of Supply research establishment in south-west England—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting G.339/50A (March 31).

TECHNICAL OFFICER (man or woman) IN THE ELECTRICAL ENGINEERING SECTION of the Technical and Scientific Register—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting D.114/51A (March 31).

WARDEN (graduate, who will be required to take some part in university teaching) of Stephenson Hall—The Registrar, The University, Sheffield (March 31).

PHYSICIST or ELECTRICAL ENGINEER (Principal Scientific Officer grade) with a high-class honours degree with research experience in telecommunications with special emphasis on all radio telephony methods and high-speed telegraphy, a PHYSICIST (Senior Scientific Officer grade) with a high-class honours degree with research experience and a considerable knowledge of electronic circuitry, and a PHYSICIST or ELECTRICAL ENGINEER (Senior Scientific Officer grade) with a high-class honours degree with experience in telecommunication research with emphasis on radio telephony and high-speed telegraphy problems, in the Royal Naval Scientific Service—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.4011/51 (April 5).

AERONAUTICAL ENGINEERS (Principal Scientific Officer grade) at the Royal Aircraft Establishment, Farnborough, to lead the Armament Installation Section, covering design and development of bomb carriers and associated equipment, development of aircraft armament installations, and stressing and strength testing of armament stores for carriage in aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting C.161/51A (April 7).

AGRONOMIST (Ref. G.7/51A) with university degree in agriculture and special qualifications in crop husbandry, and considerable experience of such work on a University farm or other experimental stations, a HORTICULTURIST (Ref. G.17/51A) with university degree in agriculture and sound practical experience, and a SUPERINTENDENT OF LIVESTOCK (Ref. G.103/51A) with a degree or diploma in agriculture and good practical experience in livestock management, etc., under the Government of Cyrenaica—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (April 7).

HISTOLOGIST to collaborate in researches on endocrinology of lactation and reproduction and other research projects involving histological studies—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, Berks, quoting 51/1 (April 7).

MECHANICAL and ELECTRICAL ENGINEERS, grades II and III, in the Ministry of Supply: (Ref. No. C.149/51A), MECHANICAL AND ELECTRICAL ENGINEERS for (*a*) the maintenance and general service of large factories, (*b*) the control and organization of inspection of engineering and aeronautical equipments and machine tools, (*c*) administration duties concerned with production, (*d*) design and development work; MECHANICAL ENGINEERS for (*e*) light or heavy engineering planning and production, (*f*) development of production processes, (*g*) time and motion study; (Ref. No. D.72/51A), ELECTRICAL ENGINEERS for (*h*) electronics—research and inspection, (*i*) radio and radar equipment—research and inspection—The Ministry of Labour and National Service, Technical and Scientific Register (K), York House, Kingsway, London, W.C.2, quoting the appropriate Ref. No. (April 7).

PHYSICIST IN THE CARBONIZATION SECTION OF THE CENTRAL RESEARCH ESTABLISHMENT at Stoke Orchard, Cheltenham, to carry out research into the physical properties of fluids—The National Coal Board, Establishments (Personnel), Hobart House, Grosvenor Place, London, S.W.1, quoting TT/300 (April 7).

PROFESSOR OF PREVENTIVE MEDICINE, and a SENIOR LECTURER IN ANIMAL PRODUCTION, in the Faculty of Veterinary Science of the University of Queensland—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 7).

LECTURER IN MATHEMATICS (applied mathematics), an ASSISTANT LECTURER IN ZOOLOGY, and an ASSISTANT LECTURER IN PHYSICS—The Principal, Royal Holloway College, Englefield Green, Surrey (April 9).

ASSISTANT PROFESSOR OF ENGINEERING—The Registrar, University College, Singleton Park, Swansea (April 11).

RESEARCH FELLOWSHIP IN PHOTOGRAPHIC SCIENCE—The Clerk to the Governors, Imperial College of Science and Technology, Prince Consort Road, London, S.W.7 (April 12).

LECTURER IN MATHEMATICS in the Training Department—The Warden, Goldsmiths' College, New Cross, London, S.E.14 (April 14).

SENIOR LECTURER or LECTURER IN BIOCHEMISTRY—The Registrar, The University, Sheffield (April 14).

SENIOR RESEARCH OFFICER or RESEARCH OFFICER, PHYSICAL CHEMIST or BIOCHEMIST, in the Biochemical Unit, Wool Textile Research Laboratory, Melbourne—The Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting No. 3311 (April 14).

BIOLOGIST (to specialize in the investigation of grass diseases as they affect sports turf), and an ADVISORY OFFICER (with a recognized diploma or degree in botany or agriculture)—The Director, St. Ives Research Station, Bingley, Yorks (April 15).

PROFESSOR OF BOTANY at Rhodes University College, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (April 15).

LECTURER IN PHYSIOLOGY—The Secretary, Queen's University, Belfast (April 16).

RAMSAY MEMORIAL FELLOWSHIPS FOR CHEMICAL RESEARCH—The Joint Honorary Secretaries, Ramsay Memorial Fellowships Trust, University College, Gower Street, London, W.C.1 (April 17).

ASSISTANT LECTURERS (2) IN THE DEPARTMENT OF ZOOLOGY—The Registrar, University College, Cathays Park, Cardiff (April 20).

READERSHIP IN PHYSICS at St. Mary's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 23).

SHELL RESEARCH STUDENTSHIP IN CHEMICAL ENGINEERING—The Shell Professor of Chemical Engineering, Department of Chemical Engineering, Tennis Court Road, Cambridge (April 25).

ASSISTANT LECTURER (honours graduate in physics or electrical engineering) IN AUDIOLOGY—The Registrar, The University, Manchester 13 (April 28).

ASSISTANT LECTURERS (3) IN PHYSICS—The Registrar, The University, Manchester 13 (April 30).

I.C.I. RESEARCH FELLOWSHIPS IN PHYSICS, CHEMISTRY, METALLURGY, ENGINEERING or an allied subject—The Registrar, University of Wales, University Registry, Cathays Park, Cardiff (April 30).

PRINCIPAL—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (April 30).

ASSISTANT LECTURER IN THE DEPARTMENT OF APPLIED MATHEMATICS—The Registrar, The University, Liverpool (May 1).

READERSHIP IN MATHEMATICS at Queen Mary College—The Academic Registrar, University of London, Senate House, London, W.C.1 (May 1).

SENIOR LECTURER IN THEORETICAL PHYSICS—The Secretary of Faculties, University Registry, Oxford (May 1).

ASSISTANT DIRECTOR (chemical engineering) and an ASSISTANT DIRECTOR (plastics and high polymers) at the National Chemical Laboratory, Poona—The Secretary, Council of Scientific and Industrial Research, 'P' Block, Raisina Road, New Delhi, India; or the High Commissioner for India, General Department, India House, Aldwych, London, W.C.2, quoting No. 4/55D (New Delhi, May 5).

ASSISTANT LECTURER IN PURE MATHEMATICS—The Registrar, University College, Hull (May 5).

LECTURER IN MATHEMATICS, a SENIOR LECTURER IN ORGANIC CHEMISTRY, and a LECTURER IN PHYSICS, at the New England University College (University of Sydney), New South Wales—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (May 14).

BOOTS RESEARCH SCHOLARSHIP at the Long Ashton Agricultural and Horticultural Research Station—The Registrar, The University, Bristol (May 31).

GEOLOGISTS at the Geological Survey and Museum—The Secretary, Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S.168/51 (May 31).

LECTURER IN VETERINARY PREVENTIVE MEDICINE, and a LECTURER IN VETERINARY PHARMACOLOGY—The Registrar, The University, Liverpool (May 31).

LECTURERS and ASSISTANT LECTURERS IN EXPERIMENTAL or THEORETICAL PHYSICS—The Secretary, The University, Aberdeen (June 1).

CHEMIST (with first-class honours) for work on the chemistry of wool keratin and allied proteins, and a CHEMIST (with first- or second-class honours) to develop radio-tracer methods for protein analysis—The Secretary, Wool Industries Research Association, Torridon, Headingley, Leeds 6.

HEAD OF THE DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING—The Principal, Technical College, Queen Street South, Huddersfield.

METALLURGISTS, PHYSICISTS and PHYSICAL CHEMISTS, to undertake a wide range of duties in normal and radioactive metallurgy, including physical metallurgy, crystallography, physics, properties of metals and alloys, corrosion, powder metallurgy and chemical thermodynamics, at Risley, near Warrington, Salwick, near Preston, and Windscale Works, Sellafield—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs (stating post applied for and location preferred).

PHYSICAL CHEMIST (with an honours degree in science, and preferably postgraduate experience in physical chemistry) for work on problems relating to fundamental and technical aspects of wool—The Secretary, Wool Industries Research Association, Torridon, Headingley, Leeds 6.

PROFESSOR OF MATHEMATICS—The Secretary, Royal Technical College, George Street, Glasgow, C.1.

RESEARCH ASSISTANT IN THE DEPARTMENT OF BOTANY—The Clerk, Birkbeck College, Breams Buildings, London, E.C.4.

RESEARCH CHEMISTS IN THE DIVISION OF ATOMIC ENERGY (Production), APPLIED RESEARCH DEPARTMENT, Windscale Works, Sellafield, to undertake chemical and radiochemical research work associated with atomic energy development—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, Lancs, quoting A.R.D/2/8.

SCIENTIFIC OFFICER (temporary), for work on beans—The Secretary, National Institute of Agricultural Botany, Huntingdon Road, Cambridge.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Colonial Office. Colonial Research, 1949–50. Reports of the Colonial Research Council, Colonial Products Research Council, Colonial Social Science Research Council, Colonial Medical Research Committee, Committee for Colonial Agricultural, Animal Health and Forestry Research, Colonial Insecticides, Fungicides and Herbicides Committee, Colonial Economic Research Committee. (Cmd. 8063.) Pp. 155. (London: H.M. Stationery Office, 1950.) 3*s.* 6*d.* net. [211

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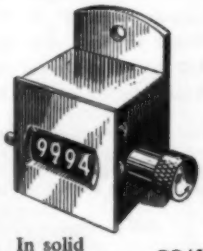

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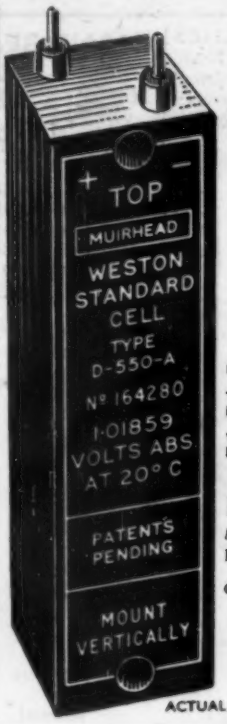

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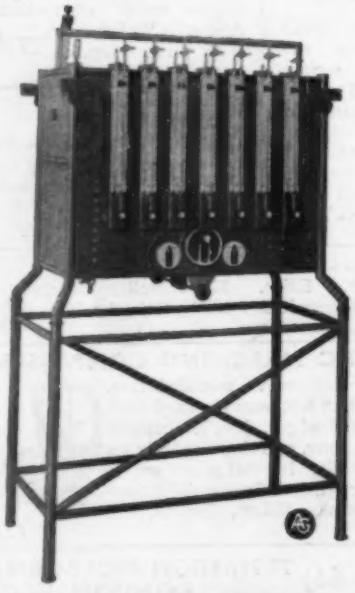

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